

MUNICIPAL SOLID WASTE LANDFILL OPERATION AND MANAGEMENT WORKBOOK



Revised April 2018

Preface

In many ways, constructing, operating and maintaining a municipal solid waste landfill is similar to constructing, operating, and maintaining a highway, dam, canal, bridge, or other engineered structure. The most important similarity is that landfills, like other engineered structures, must be constructed and operated in a manner that will provide safe, long-term, and reliable service to the communities they serve. Proper design, construction, operation, monitoring, closure and post-closure care are critical because after disposal the waste can be a threat to human health and the environment for decades to centuries.

This workbook is intended to provide municipal landfill operators and managers in Wyoming with the fundamental knowledge and technical background necessary to ensure that landfills are operated efficiently, effectively, and in a manner that is protective of human health and the environment.

This workbook contains information regarding basic construction and operation activities that are encountered on a routine basis at most landfills. The basic procedures and fundamental elements of landfill permitting, construction management, monitoring, closure, post-closure care, and financial assurance are also addressed. The workbook includes informative tips and information that landfill operators and managers can use to conserve landfill space, minimize the potential for pollution, reduce operating costs, and comply with applicable rules and regulations. In addition to this workbook, operators and managers need to become familiar with the Wyoming Solid Waste Rules and Regulations applicable to municipal solid waste. The DEQ also provides numerous guidelines that may help understand regulatory requirements in more detail. This information may be found at the DEQ's website: <http://deq.wyoming.gov/>

Sections 1-3 of this workbook should be considered an "operator's module". These sections contain basic information for landfill operators. Sections 4-9 should be considered a "manager's module". These sections contain more detailed information that may be more relevant for landfill managers.

The Department of Environmental Quality, Solid and Hazardous Waste Division, Solid Waste Permitting and Corrective Action Program (DEQ) has prepared a short training course and two tests to accompany this workbook. While this training and testing is not mandatory by rule, it may be required because it has been specified as a training requirement in a landfill's permit application. Many landfill operators use these resources to help ensure that landfill personnel have the basic skills necessary to do their jobs.

The first test offered by DEQ is the "Operator Examination". This test is based on the information in Sections 1-3. Upon passing this test, an individual will receive operator certification from the DEQ. The second test is the "Manager Examination". This test is based on the information in Sections 4-9. Upon passing both the Operator and Manager Examination, an individual will receive manager certification from the DEQ. This training and testing is usually offered by the DEQ at the annual seminar for the Wyoming Solid Waste and Recycling Association.

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SECTION 1

THE MUNICIPAL SOLID WASTE LANDFILL

SECTION 1

THE MUNICIPAL SOLID WASTE LANDFILL

TRAINING OBJECTIVES:

- 1) To identify the various types of landfills and the advantages and disadvantages of selected fill methods.
- 2) To familiarize landfill operators and managers with the types of training that may be required for their positions and the educational resources available to fulfill those requirements.

PART A. METHODS OF OPERATION

Wyoming's municipal solid waste (MSW) landfills were once called sanitary landfills and were historically classified as Type I or II based primarily on the daily volume of waste received. There were more stringent standards for larger Type I landfills. A January 3, 2017 rule change eliminated landfill classifications and all municipal solid waste landfills are now treated alike.

A MSW landfill is a solid waste management facility that utilizes an engineered method of land disposal, primarily for municipal solid wastes. An engineered method of landfilling means that wastes are handled at a disposal facility that is designed, constructed and operated in a manner protective of human health and the environment.

There are two basic methods of landfill operation, the area fill and the trench fill. In many cases, landfills are operated as a combination of the area fill and trench fill methods, combining below-grade and above-grade landfilling methods for optimum flexibility and maximum site use.

Area Fill Method:

The area fill method, sometimes known as the progressive slope or ramp method, involves construction of successive cells of waste that are compacted against a slope. Waste is typically off-loaded either on undisturbed ground or on a prepared tipping pad. Wastes are then pushed uphill onto a starter berm or sloped bank in lifts and then compacted. Over a typical operating day, wastes are placed, compacted, trimmed and covered with soil. This daily accumulation of wastes is generally referred to as a cell. Area fills are usually located in moderately rolling topography or in large pits, ravines or canyons if cover material sources are readily available. Cover material for the operation is usually obtained from previously constructed stockpiles, off-site borrow areas or adjacent areas of higher elevation (cut areas). The area fill method is

illustrated in Figure 1A-1.

Typical Operating Techniques for the Above Grade Area Fill Are:

- construct a starter berm or sloped bank
- construct a liner and leachate collection system as required
- deposit refuse at bottom of slope for best compaction and control of blowing litter
- spread and compact refuse against slope of previous lift, progressing horizontally along slope
- cover waste daily with 6" of routine (daily) cover
- for any area that will not receive waste for 180 days, add an additional 12" of intermediate cover
- no later than 30 days after the last known waste is received in each unit, begin closure of the unit by installing final cover over any routine or intermediate cover already in place. Minimum final cover consists of a minimum 18" compacted infiltration layer overlain by an adequate frost protection layer and 6" of revegetated earthen material (topsoil).
- continue using progressive slope

Advantages:

- does not require excavation of trenches
- useful in areas where the terrain may be unsuitable for trench operations
- can accommodate high traffic volumes since the working face is not limited by the size of an excavation

Disadvantages:

- cover material may have to be imported
- potential exists for greater litter problems
- larger overall area/volume ratio (greater amount of landfill surface area used per volume of waste deposited) may result in higher costs
- topographic control not as obvious as for trench operation

Trench Fill Method:

In a trench fill operation, solid wastes are spread and compacted in an excavated trench. Trench fill operations are typically used in relatively flat terrains but can be adapted to a wide variety of topographic conditions. Cover material can be obtained from excavation of one or more complete trenches followed by stockpiling, or it can be obtained by gradually excavating a new trench adjacent to the active trench. An example of a trench fill operation is depicted as Figure 1A-2.

Typical Operating Techniques for the Trench Fill Are:

- excavate trench to depth prescribed by plans
- place liner layer and leachate collection system as required
- leave divider of two feet or more of undisturbed earth between trenches
- dump refuse, preferably at the bottom of the trench, spread and compact in layers on a slope
- proportion width of trench to size of operation

Advantages:

- not usually necessary to import cover material
- can be operated with a minimum working face exposed
- subgrade disposal may provide better litter control
- lower area/volume ratio (smaller amount of landfill surface area used per volume of waste deposited) may reduce cost relative to above grade area fills

Disadvantages:

- not suitable in geologic areas with high excavation costs or shallow ground water
- leachate collection may be more difficult/expensive in individual trenches
- loss of landfill volume due to the "between trench" areas
- trench depths and side slopes depend on soil types and stability
- trench size may be insufficient to handle unexpected high traffic volumes

SECTION 1. THE MUNICIPAL SOLID WASTE LANDFILL

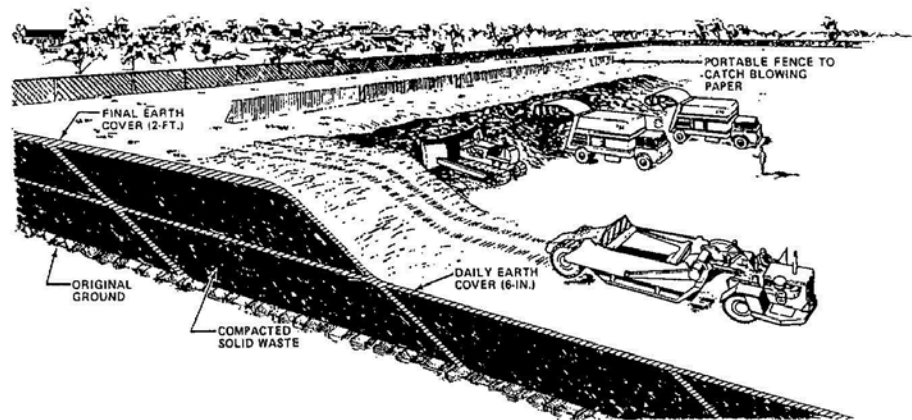


FIGURE 1A-1 :AREA LANDFILL OPERATION

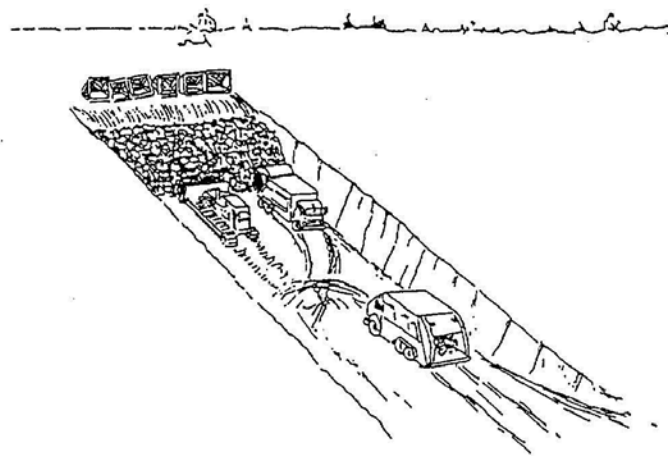


FIGURE 1A-2 :TRENCH METHOD OF LANDFILLING

Continuous Trench Fill Method:

The continuous trench fill method is a special category of trench fill in which cover material is obtained by progressive trench excavation. An example of continuous trench filling is depicted in Figure 1A-3.

Advantages:

- minimizes earth moving by obtaining cover material just ahead of the disposal operation by progressively moving a trench sidewall, by extending the trench length, or a combination of both
- lower area/volume ratio (smaller amount of landfill surface area used per volume of waste deposited) may reduce cost relative to above grade area fills and trench fills
- maximizes site capacity and life by eliminating between-trench loss of space
- leachate collection may be less difficult and expensive
- minimizes double-handling of cover material and can reduce overall operating costs

Prepared Refuse Fill Method:

In a prepared refuse fill, the waste materials are processed prior to actual landfilling by trench, area, or combination methods. Two of the most common techniques are shredding by mechanical action, or baling by compression into large rectangular blocks. When baled wastes are landfilled, the standard landfill operating methods are often altered to accommodate the geometry of the rectangular bales. For example, changes in operating method may include using a forklift to position bales in a trench and eliminating cover material on the exposed vertical faces of the bales.

Advantages of Baled Wastes:

- higher waste density compared to small compaction equipment (up to 1,700 lb/cy) that increases site life, although larger compactors may achieve similar or better compaction
- improved aesthetics (appearance) over unprocessed waste
- less routine cover is often required, reducing cover costs
- may provide better litter control
- lower area/volume ratio (smaller amount of landfill surface area used per volume of waste deposited)
- hauling costs may be reduced if waste is processed at transfer stations or a central location

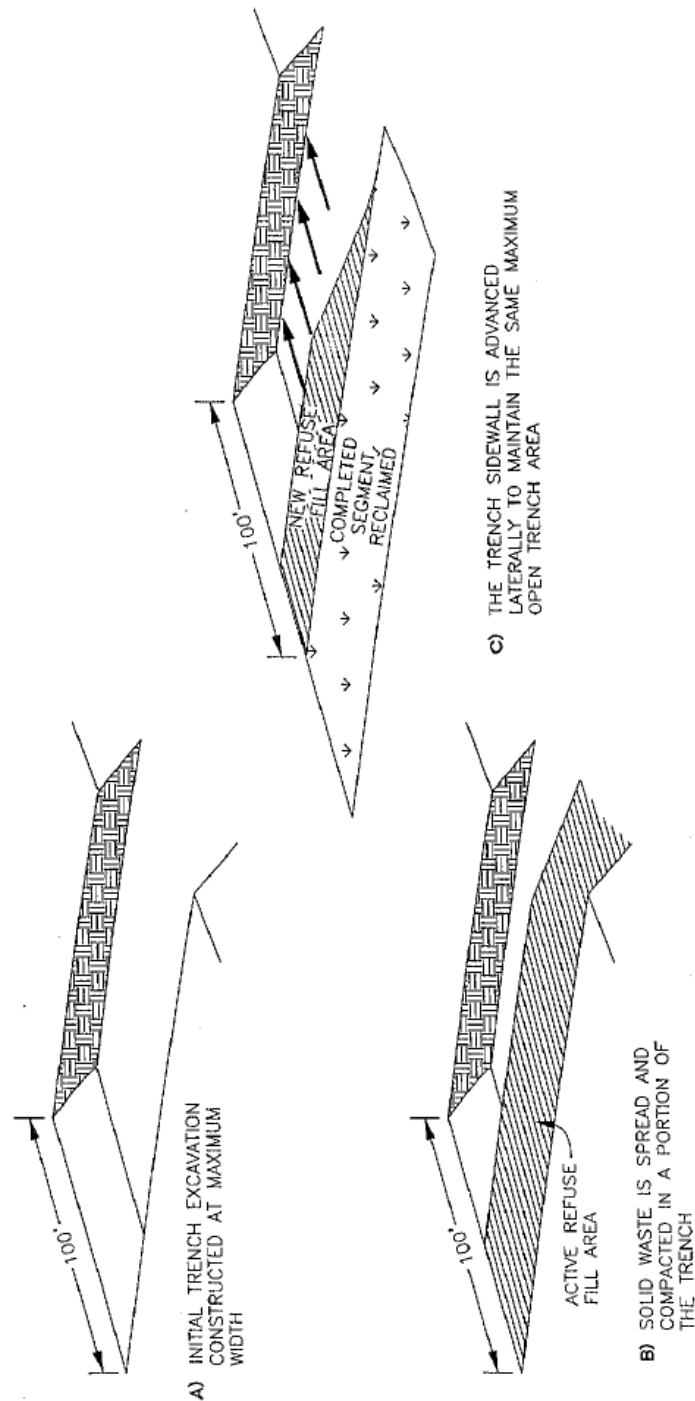


FIGURE 1A-3 :CONTINUOUS TRENCH FILL

WDLWC2RF

Disadvantages of Baled Wastes:

- initial cost of equipment
- ongoing costs of operation and maintenance
- potential equipment breakdown

PART B. SOLID WASTE MANAGER TRAINING REQUIREMENTS

A solid waste manager is the person who has primary responsibility for the daily management and operation of the landfill. At small disposal facilities, the solid waste manager and the landfill operator may be the same person. At larger facilities, the designated solid waste manager may be the head operator, the Director of Sanitation, the Director of Public Works or the City Engineer. Regardless of title, the solid waste manager is responsible for daily landfill operations.

To insure that each landfill facility is managed and operated by qualified personnel, Wyoming regulations require solid waste managers to meet specified training requirements. The training requirements can help solid waste managers keep up to date with changes in rules and regulations as well as new developments and innovations in the solid waste industry. Training requirements are outlined in the facility's approved operating plan. Many facility operating plans include training requirements for all landfill personnel including the solid waste manager.

Each Solid Waste Landfill Facility:

- must be operated by a solid waste manager who has met the training requirements in the approved permit application (if the qualified solid waste manager position becomes vacant, a new solid waste manager who meets the requirements must be designated within 6 months)
- must maintain records of training and examination that are available for inspection by the DEQ

A Solid Waste Manager Is Considered to Be Qualified If He/She:

- has attended the classroom or field training program described in the approved permit
- has a working knowledge of the landfill operating plan
- has been trained in identification of PCB wastes and hazardous wastes
- has attended any mandatory training seminars sponsored by the DEQ
- is constructing and operating the landfill facility in compliance with the approved permit and the Solid Waste Rules.

Landfill Training Is Required to Be:

- completed as described in your facility's approved permit
- documented as described in your facility's approved permit
- completed in a timely manner (for example, a new solid waste manager is required to be able to demonstrate a working knowledge of the plan within 6 months following assumption of duties)

Sources of Training:

- Your own in-house training program
- This Training Manual
- Other DEQ Training Manuals, Programs and Videos (for example, a Hazardous Waste Screening Video is available)
- Wyoming Solid Waste and Recycling Association (WSWRA) Annual Meeting
- Solid Waste Association of North America (SWANA) Documents, Classes and Videos
- Books, Videos and Training Programs Offered by Private Companies
- EPA Guidance Documents and Classes
- Trade Publications, Magazines and Journals

SECTION 2

BASIC LANDFILL CONSTRUCTION

SECTION 2

BASIC LANDFILL CONSTRUCTION

TRAINING OBJECTIVES:

- 1) To familiarize landfill operators and managers with engineering plans and specifications, and provide guidance on how to read, interpret and follow the plans and specifications to ensure compliance with the approved permit.
- 2) To provide landfill operators and managers with a clear understanding of the regulatory requirements that must be met with respect to landfill construction.
- 3) To explain the rationale and intent of the regulatory standards.
- 4) To provide landfill operators and managers with methods and suggestions that will assist them in complying with the regulatory requirements.

PART A. LANDFILL DEVELOPMENT

A municipal solid waste (MSW) landfill is an engineered facility designed to provide safe, nuisance-free disposal of solid wastes. Engineered facility implies that there is a set of plans and specifications that are to be used for construction of the facility. Plans and specifications are the basis for the facility's operating permit.

It is the operator's responsibility to be completely familiar with the plans and specifications and ensure that they are followed. Each facility design is tailored to protect human health and the environment by reducing the risk of contaminant release.

Failure to follow the plans and specifications increases the probability of facility failure and exposes the owner to financial risk.

Topics in this section include:

- plans and Specifications
- reading and Understanding Plans
- following Plans

Plans and Specifications:

Plans are detailed engineering drawings which show existing characteristics and the proposed development of the facility. Plan drawings show existing conditions, site development, structures, boundaries, cross-sections, final contours, details of special construction or design features, etc.

Specifications are a written discussion of the methods and materials that will be used to construct and operate the landfill. Specifications contain performance criteria or standards which are expected to be accomplished. Major items in specifications include:

- equipment needs
- compaction and covering requirements/procedures
- environmental monitoring requirements/procedures
- engineered containment system/slope stability
- surface water control
- site development requirements/procedures
- methane/leachate control
- topsoil handling/revegetation requirements/procedures
- access restrictions/waste screening
- record keeping
- closure/post-closure

Reading and Understanding Plans:

The ability to read and understand plans is necessary to ensure that the facility is operated in compliance with the regulations and the approved permit document. The use of plans allows the operator to track landfilling progress and rate of filling and enables the operator to plan for future expansions.

There are five (5) basic types of plans necessary for the operation of a landfill:

General Facility Plan: (see Appendix A)

The purpose of the general facility plan is to show site characteristics prior to any site development. The plan is generally drawn at a scale not greater than 200 feet to the inch and not greater than five (5) foot contour intervals (see discussion on plan scale and contour interval beginning on page 3 of this part). The general facility plan illustrates the following features:

- facility boundaries, including buffer zones
- points of access
- location of soil borings, groundwater monitoring wells and methane monitoring

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wells

- location of proposed trenches or area fill locations
- working area/perimeter fire lane
- locations of any facility buildings
- working area/perimeter fence

Development Plan: (see Appendix A)

The purpose of the development plan is to show orderly development and use of the facility throughout the life of the site. The plan is generally drawn at the same scale as the general facility plan and illustrates the following information:

- excavation plans for development of trenches or preparation of area fill locations
- development of temporary surface water diversion structures
- access to active waste disposal areas
- daily cover stockpile locations
- topsoil storage pile locations
- litter screen placement information
- location of special waste management or disposal areas
- other details pertinent to the development and use of the facility

Final Contour Plan: (see Appendix A)

The purpose of the final contour plan is to show proposed final contours and permanent surface water diversion structures. The plan may also show the proposed final use of the site. The final contour plan is generally drawn at the same scale as the general facility plan.

Cross-Sections: (see Appendix A)

A cross-section is drawn to show a landfill as if a section of fill was sliced and the end of the slice is viewed. Cross-sections show the vertical limit of excavation and filling, the distance between the top of the water table and the bottom of the waste disposal area, and covers and liners. Cross-sections are also used to calculate volumes.

Details:

Details are drawn to show special construction or design features, including:

- litter catch screens or fences
- working area/perimeter fencing
- access roads
- trench or area fill method
- special waste areas

SECTION 2. BASIC LANDFILL CONSTRUCTION

- systems used for monitoring, collection, treatment and disposal of leachate
- groundwater monitoring well design
- methane gas venting and monitoring system
- surface/subsurface drain systems to control run-on, run-off and/or inflow
- components of an engineered containment system
- construction quality assurance/quality control (QA/QC) plans

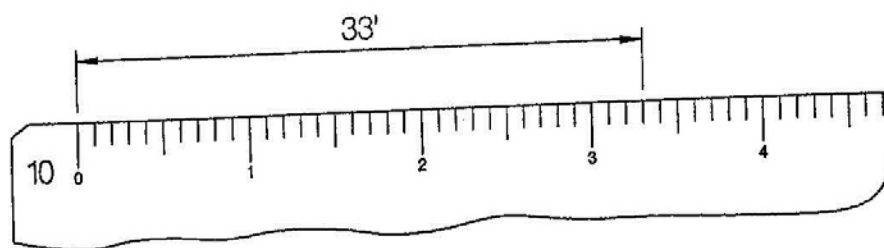
To interpret plans, an understanding of plan scale, contour lines, slope, area and volume is essential.

Plan Scale:

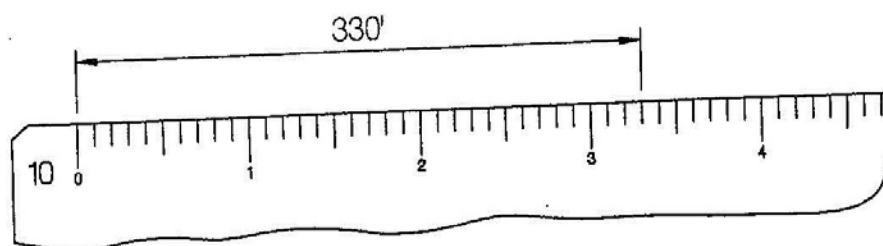
All engineered plans are drawn to a scale. Plan scale is the relationship between measurements on the plan and measurements on the ground. For example, a scale of 1"=100' means that 1 inch measured on the plan drawing equals 100 feet measured in the field. To determine the distance on the ground, an engineering scale is used to measure directly the distance between two points on the plan.

The engineer's scale is graduated in units of one (1) inch divided into 10, 20, 30, 40, 50 and 60 parts. These scales can be enlarged or reduced by multiplying or dividing by a factor of 10. For example, for a plan scale of 1"=100', the 10-scale is used and each 1 inch increment represents 100 feet. See Figure 2A-1 for examples of reading an engineer's scale.

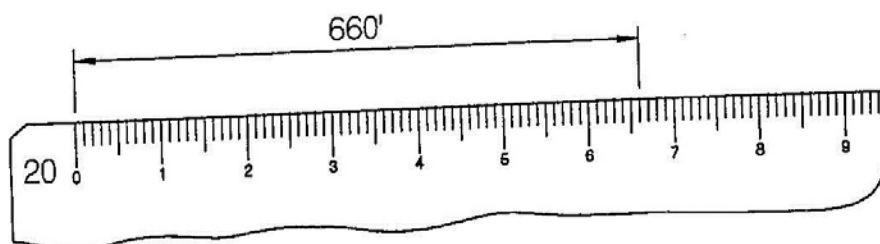
SECTION 2. BASIC LANDFILL CONSTRUCTION



(a) 1" = 10'



(b) 1" = 100'



(c) 1" = 200'

Figure 2A-1
Reading Engineers Scales

A ruler can also be used to make measurements on the plan. To determine the distance on the ground, the measurement on the plan must be multiplied by the plan scale as follows:

$$\text{Distance on ground (feet)} = \text{Measurement on plan (inches)} \times \text{Plan Scale (feet/inch)}$$

Example 1:

The distance between two points on a plan sheet is measured to be 4.3 inches. Determine the actual distance on the ground if the plan scale is 1"=200'.

$$\text{Distance on ground} = 4.3 \text{ inches} \times 200 \text{ feet/inch} = \underline{860 \text{ feet}}$$

Contour Lines:

Contour lines are used on plan view drawings to show changes in elevation. Contour lines add the third dimension to a flat piece of paper. Contour lines:

- are lines that connect points of the same elevation
- never cross one another
- represent steep slopes when spaced close together
- represent gentle slopes when spaced farther apart
- represent a summit or depression when closed
- represent a difference in elevation based on a fixed base datum, such as sea level. In other words, an elevation of 6,000 feet above sea level means that point is 6,000 feet vertically above sea level.

A contour map is used to determine the elevation of any point on a site. If you need to determine the elevation of a point that falls between two contour lines, estimate the elevation based on the elevation of the two contour lines. Drainage patterns can also be determined since drainage flows perpendicular to (across) contour lines.

To determine the difference in elevation between two points using contour lines, count the number of lines between the points and multiply that number by the difference in elevation between the lines (contour interval). Do not count the first line as this is the starting point and does not reflect a change in elevation.

Figure 2A-2 illustrates the properties of contour lines.

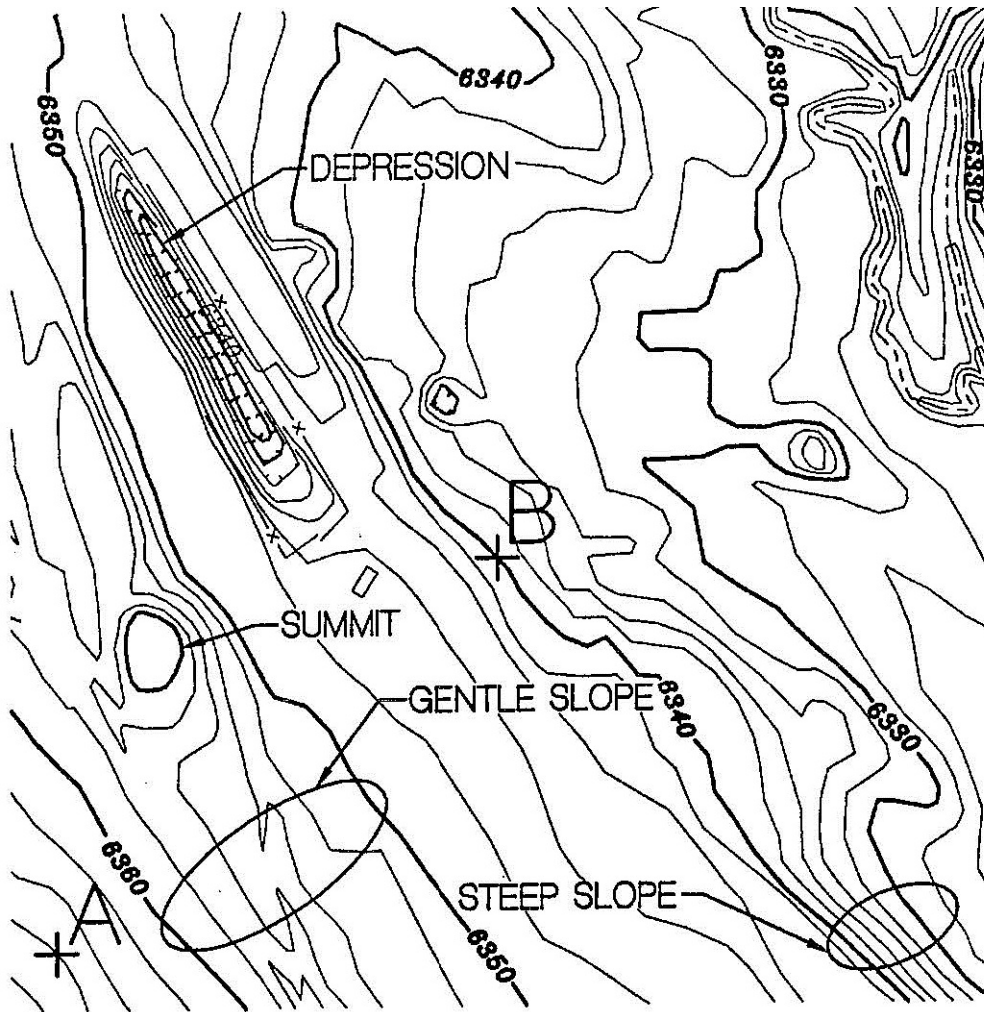


Figure 2A-2
Contour Map

Example 2:

Determine the difference in elevation between points A and B in Figure 2A-2:

The number of contour lines between A and B = 13
The contour interval = 2 feet

The difference in elevation between A and B = $13 \times 2 = \underline{26 \text{ feet}}$

Slope, Area and Volume:

Refer to Appendix B for a detailed discussion of these topics.

Following Plans:

Maintaining proper locations and elevations is the key to following plans. To do this, existing elevations and proposed cut or fill elevations must be determined based on plans. The following items are essential to following plans:

- Permanent grade stakes/elevation markers are necessary to use as a reference point. These could be monuments or lag screws in a tree, utility pole or on a building. Do not use items that may be moved during construction of the fill such as fence posts, roads, etc.
- Temporary grade stakes can be placed in areas where filling is occurring to obtain slopes and elevations.
- Grades must be checked against plans periodically.

The operator must know the limits of his/her ability to accomplish certain aspects of following plans. There are certain aspects that should be left to a registered engineer or surveyor. However, there are many tasks that can be done by the operator.

Appendix C provides some basic techniques for obtaining measurements in the field including distance, elevation and slope.

PART B. FIRE LANE AND BUFFER ZONE

To prevent fires in the landfill facility from spreading to off-site areas and to prevent fires from off-site areas from spreading onto the landfill facility and into the active waste disposal area, fire lanes must be constructed around all active solid waste management units or within the perimeter fence. Fire lanes also provide access for firefighting equipment. Although fire lanes are only required around the active waste disposal areas, some sites construct the fire lanes within the buffer zone.

The fire lane must be:

- a minimum of ten (10) feet wide
- within the working area/perimeter fence or around active waste management areas
- may be constructed within the 20 foot buffer zone (see the left or western portion of Figure 2C-1)
- maintained (cleared) periodically to keep a bare space

Buffer zones consist of an undisturbed area within the perimeter of the landfill facility at least twenty (20) feet wide. Buffer zones are required:

- to allow room for proper reclamation
- to allow placement of groundwater and methane monitoring wells

Figure 2C-1 shows the relationship between fire lanes and buffer zones.

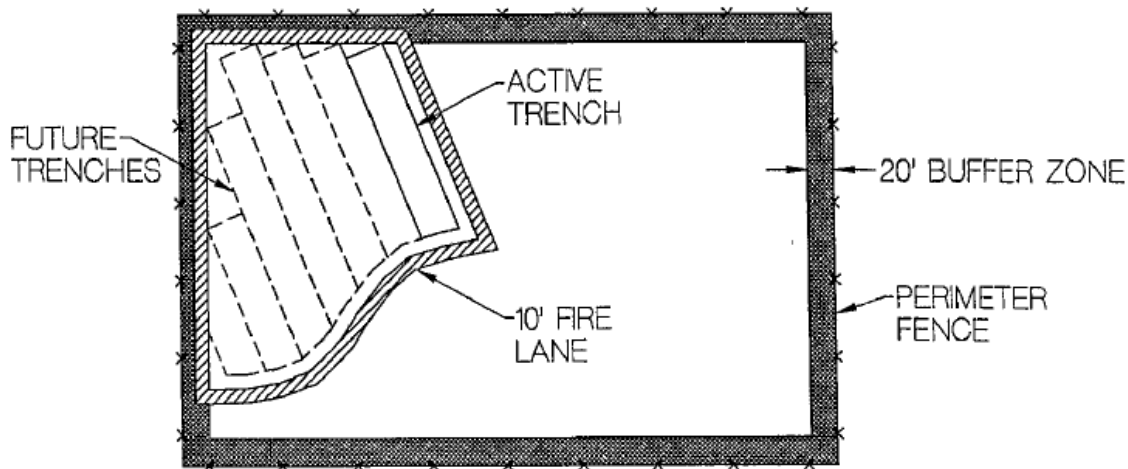


Figure 2C-1
Fire Lane/Buffer Zone

PART C. ACCESS ROAD

To maintain the smooth operation of the landfill and to provide a safe environment for the public using the landfill facility, access roads must be well constructed and maintained.

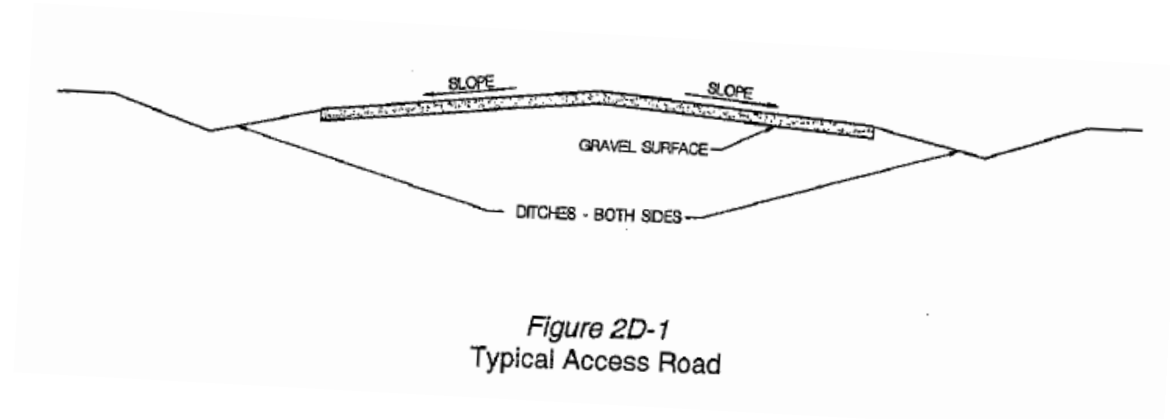
Access roads must be constructed to enable use under severe weather conditions, especially rain. Gravel access roads should consist of a high quality crushed road base surfacing which is crowned to provide adequate drainage of water away from the surface.

Maintenance of the gravel access roads includes blading as needed to ensure adequate drainage and treatment to control dust problems. Dust control treatments may include asphalt emulsions or chemical stabilizers.

Access roads must be constructed from the point of access to the active waste disposal area and to each specialty waste management/disposal area. This will help ensure that wastes are not disposed in areas that are prohibited for disposal. All

access roads should be designed with a minimum width of twenty (20) feet.

Figure 2D-1 illustrates the properties of a typical access road.



PART D. STRUCTURAL STABILITY

To ensure stability of liners, leachate collection systems, final covers and surface water diversion structures, engineering measures must be incorporated into the landfill design and construction if the facility is located in:

- unstable areas
- fault areas
- seismic impact zones

Unstable Areas:

Unstable areas include those areas that have poor soils for foundations or are susceptible to mass movement. Areas with soils that make poor foundations have soils that are expansive or settle suddenly. Areas subject to mass movement can be situated on steep or gradual slopes and tend to have rock or soil conditions that are conducive to down slope movement of soil, rock and/or debris under the influence of gravity (e.g. avalanches, landslides, debris slides and flows and rock slides).

Methods for stabilizing natural and human-made slopes in unstable areas include:

- changing slope geometry (see Figure 2F-1)

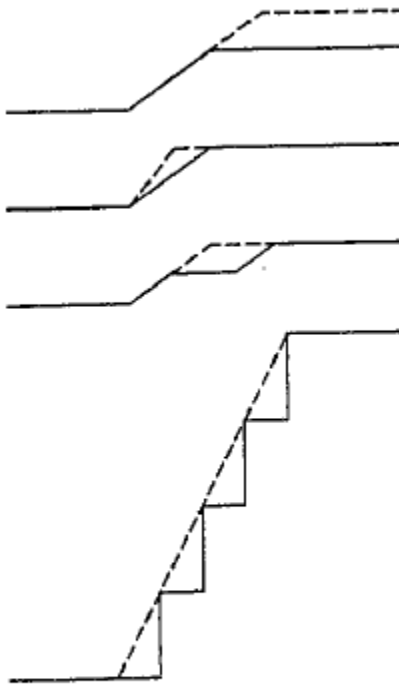


Figure 2F-1
Changing Slope Geometry

- construction of earth berm fill at the toe of the slope (see Figure 2F-2)



Figure 2F-2
Earth Berm Fill

- construction of retaining structures (see Figure 2F-3)

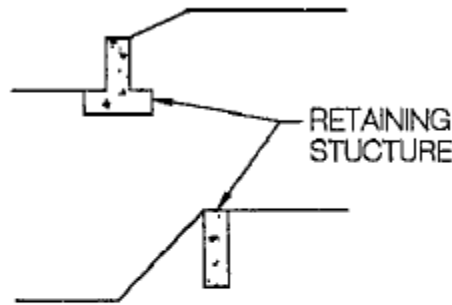


Figure 2F-3
Retaining Structures

- additional procedures for stabilizing slopes include:
 - use of geotextiles and geogrids to provide additional strength
 - installation of drains at the toe of the slope to relieve excess water pressures
 - wellpoint pumping to lower groundwater levels
 - controlling surface drainage to decrease infiltration

Fault Areas:

New landfill units, existing units, and lateral expansions shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time (within the last 10,000 years) unless the operator demonstrates that an alternate setback distance of less than 200 feet (60 meters) will prevent damage to the facility and be protective of human health and the environment. Fault means a fracture or a zone of fractures in any material along which strata on one side have been displaced with respect to that on the other side. Displacement means the relative movement of any two sides of a fault measured in any direction.

Considerations for modifications to landfills in fault areas include:

- for areas with high probabilities of high accelerations (horizontal), seismic designs should be developed
- seismic stability analysis of landfill slopes should be performed to guide selection of materials and grades for slopes

- the use of flexible pipes and secondary containment systems for leachate collection

Seismic Impact Zones:

Landfills shall not be located in seismic impact zones unless a demonstration is made that the liners, leachate collection systems, final covers and surface water diversion structures are designed to resist the seismic forces exhibited at the site. Seismic impact zone means an area with a ten percent (10%) or greater probability that the maximum horizontal acceleration in hard rock, expressed as a percentage of the earth's pull (g), will exceed 0.10g in 250 years. Hard rock does not include man-made materials such as fill, concrete and asphalt or unconsolidated earth materials or soil lying at or near the earth surface.

Considerations for modifications to landfills in seismic impact zones include:

- shallower waste side slopes
- more conservative design of dikes and run-off controls
- the use of flexible pipes and secondary containment systems for leachate collection

PART E. SLOPE STABILITY FOR EXCAVATIONS

To ensure the stability of excavations and to protect the public and landfill employees, any excavation shall not exceed a ratio of 1.5H:1V unless the operator can demonstrate that alternative designs will be in compliance with the open excavation requirements of Wyoming Occupational Health and Safety Rules and Regulations.

To demonstrate that alternate designs (steeper slopes) are in compliance, slope stability analyses can be performed for both excavated side slopes and aboveground embankments to verify the structural integrity of a cut slope or dike (see Section 5, Part A of this workbook).

PART F. SURFACE WATER RUN-ON AND RUN-OFF STRUCTURES

To minimize the amount of surface water entering the landfill facility and active waste disposal areas and to prevent moisture infiltration from ponding of surface water over filled areas, run-on structures are constructed. These structures collect and redirect the surface waters away from the facility and disposal areas.

Run-off structures collect and control run-off from the active portion of the landfill which may have contacted waste materials. Run-off structures are also used to protect

the final cover by collecting and controlling run-off from the closed portion of the landfill.

Surface water run-on and run-off structures must be designed and constructed to:

- Prevent flow onto the active portion of the landfill during the peak discharge from a 25-year storm;
- Collect and control run-off from the active portion of the landfill from at least the water volume resulting from a 24-hour, 25 year storm;
- Sediment control structures shall be designed and constructed in accordance with Chapter 11 of the Water Quality Division Rules and Regulations.

Refer to Section 5, Part C of this workbook for general information on the design and rationale for surface water run-on and run-off structures.

Run-on/run-off structures may include:

- dikes and berms
- channels
- terraces and benches
- chutes
- culverts
- sediment basins
- levees and floodwalls

See Figure 2H-1 for examples of run-on/run-off structures.

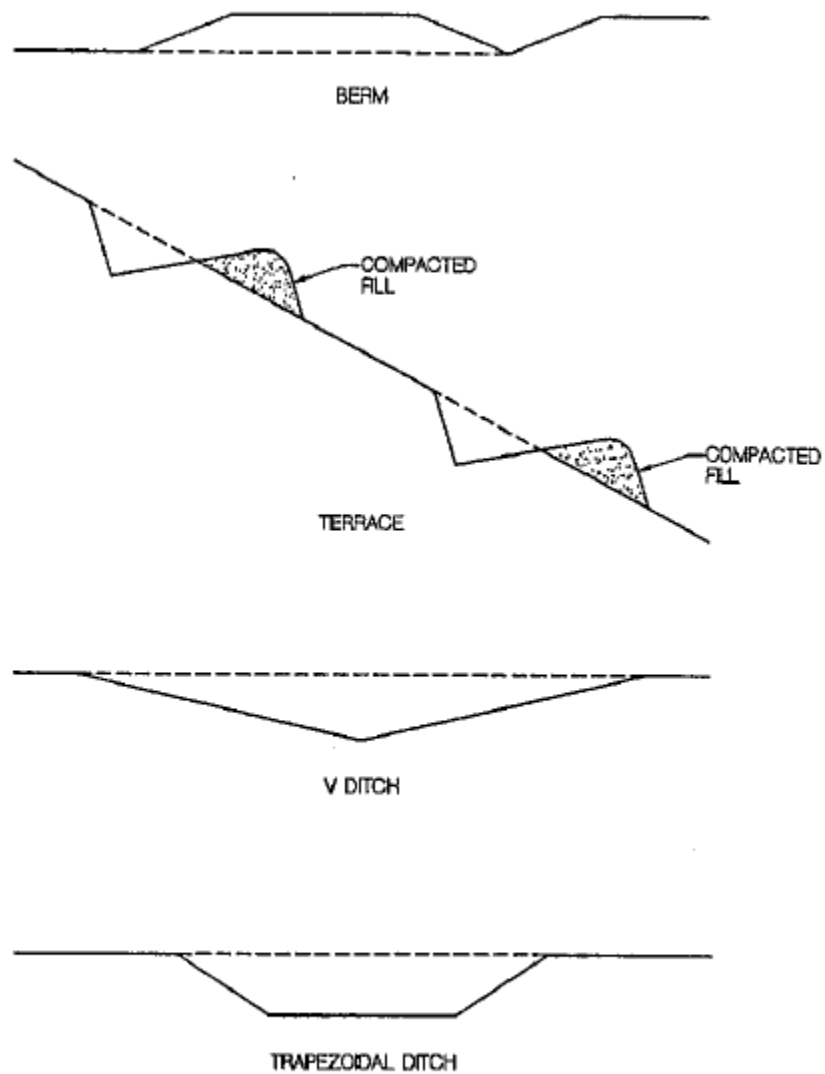


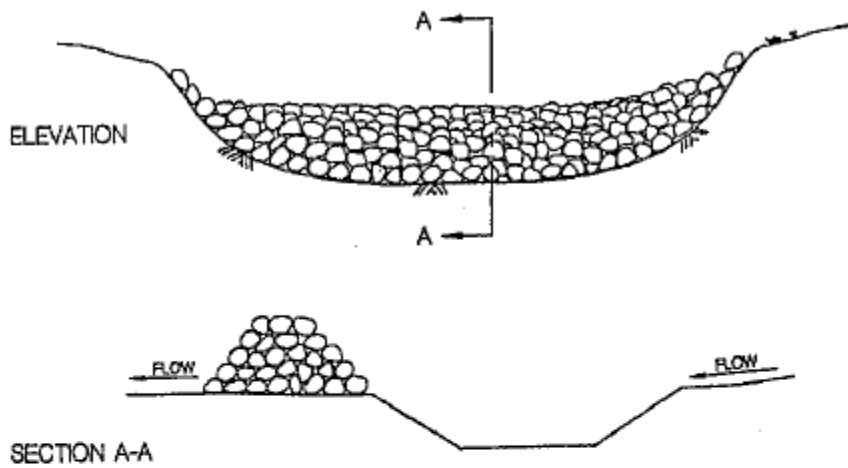
Figure 2H-1
Run-on/Run-off Structures

Erosion control measures for run-on/run-off structures include:

- vegetation
- hay bale check dams
- stone check dams
- riprap
- erosion control blankets

See Figure 2H-2 for examples of erosion control measures.

SECTION 2. BASIC LANDFILL CONSTRUCTION



STONE CHECK DAM



HAYBALE CHECK DAM

Figure 2H-2
Erosion Control Measures

A good maintenance program is of equal importance with proper design and construction of structures. Proper maintenance ensures the capacity of the structure stays at the design level. Maintenance includes:

- repairing erosion damage
- mowing vegetation
- removing any sediment or debris deposited in the structure

PART G. ENGINEERED CONTAINMENT SYSTEMS

Engineered containment systems include liners and caps (final cover). New landfill units and lateral expansions must be constructed with an engineered containment system that utilizes a composite liner and leachate collection system or in accordance with a performance based design approved by DEQ.

A performance based design is a demonstration, generally using modeling to predict the potential effects of leachate, that groundwater protection standards will not be exceeded at a point no more than 150 meters (492 feet) from a waste disposal unit boundary.

Composite liner means a system consisting of two (2) components; the upper component must consist of a minimum thirty (30) mil flexible membrane liner (FML) and the lower component shall consist of at least a two (2) foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second. A flexible membrane liner components consisting of high density polyethylene (HDPE) shall be at least sixty (60) mil thick. The flexible membrane liner component shall be installed in direct and uniform contact with the compacted soil component

Section 5, Part D of this workbook contains a detailed description of the design and construction requirements of engineered containment systems as well as a discussion on what determines which facilities need an engineered containment system.

PART H. SPECIAL WASTE MANAGEMENT AREAS

Because of certain hazards posed by these wastes, landfills which accept special wastes must design, construct and operate the waste management/disposal area in accordance with the minimum standards in Chapter 8 of the Solid Waste Rules and Regulations.

Facilities must be permitted to accept Special Wastes prior to the facility accepting the wastes for treatment and/or disposal. Solid Waste Guidelines may be available to assist operators with the management of Special Waste.

The terms "Special Waste" and "Specialty Waste" should not be confused. Special Wastes are defined in Chapter 8 of the Solid Waste Rules and Regulations as:

- scrap tires
- asbestos-containing solid wastes (friable and non-friable asbestos)
- petroleum-contaminated soils
- petroleum storage tanks

Specialty Waste include a wide variety of wastes that may require special management practices, but are not specifically regulated under Chapter 8 of the Solid Waste Rules and Regulations. Specialty Wastes include, but are not limited to:

- lead-acid batteries
- used motor oil
- LP tanks
- white goods (appliances)
- construction & demolition waste
- car bodies
- scrap metal
- dead animals
- compost
- medical waste
- e-waste
- wood waste
- green waste
- metals
- household batteries

Asbestos-Containing Solid Wastes:

Asbestos-containing solid wastes or asbestos means solid wastes containing greater than one percent (1%) by weight asbestos in any of the asbestiform varieties of: chrysotile (serpentine), amosite cummingtonite, grunerite), crocidolite (riebeckite), anthophyllite, actinolite, or tremolite, and which may be considered friable asbestos.

Friable asbestos means asbestos that, when dry, can be crumbled, pulverized or reduced to powder by hand pressure, and includes previously nonfriable asbestos after such previously nonfriable asbestos becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure.

Petroleum-Contaminated Soils: (see Section 5, Part F of this workbook)

Petroleum-contaminated soils (PCS) are solid waste consisting of any natural or manmade soil or rock material into which petroleum product has been added, excluding hardened asphalt rubble.

Petroleum Storage Tanks:

Petroleum storage tanks (PST) are underground or above ground storage tanks that have been taken out of service and which contained petroleum products, including but not limited to storage tanks that have held gasoline, diesel fuels, and used and unused motor oils.

SECTION 3
BASIC LANDFILL OPERATION

SECTION 3

BASIC LANDFILL OPERATION

TRAINING OBJECTIVES:

- 1) To provide landfill operators and managers with a clear understanding of the regulatory standards that must be met during routine landfill operations.
- 2) To explain the rationale and intent of the regulatory standards
- 3) To provide landfill operators and managers with tips and information that can be used to simplify routine landfill operations, increase efficiency of landfill operations, and reduce landfill operating costs.
- 4) To identify information and reference materials that can be used by landfill operators and managers to ensure that landfill operating expectations are achieved and that landfill operating efficiency is maximized.

PART A. DAILY COMPACTION AND COVER REQUIREMENTS

Thorough waste compaction is necessary to reduce settlement and conserve landfill space, reduce the volume of daily cover used, and minimize infiltration of rain and snow melt to protect groundwater. Thorough waste compaction is also beneficial to reduce blowing litter, and improve the appearance of the facility. Adequate waste compaction is best accomplished by:

- using a compactor or dozer with weight of at least 45,000 pounds
- spreading and compacting waste from the toe up the cell slope
- depositing waste in thin lifts (no more than 2 feet thick)
- keeping large or bulky items at the bottom of the cell
- maintaining cell slopes at 30% or less
- wheel rolling or track rolling three (3) to five (5) complete passes

All municipal landfill operators are required to place at least six (6) inches of soil cover material over wastes each day the facility is open for receipt of waste. Adequate daily cover is necessary to promote runoff away from active areas, minimize infiltration of rain and snow melt, control litter, minimize vectors and odors, prevent scavenging, and reduce the possibility of fire. Application of cover material will usually occur near the end of the operating day as the last stage of cell construction.

Your operating plan may specify that certain waste materials be covered more or less frequently, depending on the nature of the waste and the manner in which it is managed. Table 3A-1 lists a number of specialty wastes and associated cover application requirements or recommendations.

There are several things that landfill operators can do to improve the efficiency and/or effectiveness of covering and compaction:

- optimize cell shape, volume and construction
- trim compacted waste prior to application of cover material
- use steel wheeled compactors or tracked vehicles with special track pads for waste compaction
- consider using alternative daily cover materials

Optimize Cell Shape, Volume and Construction:

A cell is that portion of air space that is occupied by some volume (commonly one day's worth) of compacted and covered waste. A complete discussion of the various types of cell construction and steps that operators can follow to optimize cell size is presented in Part 3B regarding confining the working face. In general, the operator should construct refuse cells in a manner that minimizes surface area to the extent possible. This tactic is effective to confine the working face and will consume less cover material because the surface area that must be covered is smaller.

Trim Compacted Waste Prior to Application of Cover Material:

Trimming of compacted waste is typically accomplished using a dozer or compactor. The blade of the vehicle is used to trim the surface of the compacted waste so that the surface is as smooth and free of irregularities as possible. In this manner, the amount of cover material that is wasted filling void space and depressions in the cell surface is minimized.

If Possible, Use Steel Wheeled Compactors or Tracked Vehicles with Special Track Pads for Waste Compaction:

These two types of equipment provide the most efficient compaction effort and can achieve greater compaction than rubber tired vehicles or standard track vehicles. These types of compaction vehicles are identified and discussed in Part 3C of this workbook.

Consider Using Alternative Daily Cover Materials:

If approved by the DEQ, the use of alternative daily cover materials can reduce the amount of landfill air space that would otherwise be occupied by soil cover material. If the use of alternative daily cover material is considered, it is important to remember that the material must be effective to minimize infiltration of rain and snow melt, control litter, minimize vectors and odors, prevent scavenging, and reduce the possibility of fire. It is important to remember that at least six (6) inches of soil cover material will also be required no less frequently than once every 30 days as a fire control measure.

Alternative daily cover is of particular interest to smaller landfills and landfills where overall space availability is limited or expensive. Alternative daily cover materials that may be considered include, but are not limited to foam, geosynthetic fabric or panel products (blankets), spray-applied cement, tarps.

Table 3A-1. Soil Cover Application for Certain Special and Specialty Wastes

Waste Type	Cover Application
Refuse	Cover with minimum of 6 inches of soil at least daily
Friable Asbestos	Cover with minimum of 12 inches of soil daily, prior to being compacted. If the friable asbestos unit will not receive waste for more than 30 days, 12 inches of intermediate cover must also be applied.
Non-Friable Asbestos	Cover with 6 inches of soil upon receipt if the area is not subject to access restrictions; cover within 12 hours after receipt if the area is subject to access restrictions
Petroleum-Contaminated Soils	Not subject to daily cover requirements if being properly treated and may be used as daily cover with prior DEQ approval.
Medical Wastes*	Dispose in specialty waste management area such as dead animal pit and cover immediately
Dead Animals	Cover with minimum of 6 inches of soil at least daily
Clean Wood / Brush / etc.*	Cover at least once per month if not being burned

Scrap Metal / Construction - Demolition Wastes / Tires / White Goods	Cover at least once per month if not being routinely removed for salvage or recycling
Baled Waste	Cover tops and sides of bails with at least 6 inches of soil at end of day

* Recommended Cover Application

PART B. IMPLEMENTATION OF THE LITTER CONTROL PROGRAM

Municipal landfill operators must manage litter in a manner that is effective both inside and outside the landfill boundary. The purpose of the litter control program is to prevent litter from becoming a nuisance or safety hazard and to improve the appearance of the facility. Problems that can develop if litter is allowed to go uncontrolled include:

- complaints from neighbors and the public
- unsightly appearance of the facility
- increased presence of vectors
- increased risk of onsite and offsite fire as well as other safety hazards
- increased landfill operating costs
- reduced willingness of landowners to allow landfill expansion

A basic premise that should back any litter control program is that it is easier and cheaper to prevent litter at the working face than to pick it up after it has blown over the landfill area and onto adjacent property. The most common ways to prevent and minimize litter problems are to:

- confine the working face
- make effective use of litter catch screens, fences and/or enclosure
- orient trenches perpendicular to wind direction
- deposit / compact waste on the down-wind slope
- push waste short distances and minimize waste handling
- cover and/or compact waste more frequently during periods of high wind
- restrict waste deposition / handling during periods of high wind
- require incoming vehicles to cover loads
- require bagging of all incoming garbage
- conduct frequent litter inspections and clean-up

Confine the Working Face:

Keeping the working face of the active fill area as small as possible is required under the regulations and is one of the best ways to help prevent litter problems. Methods that operators should be using to confine the working face are discussed in detail in Part F of this Section.

Litter Catch Screens and Fences:

Litter catch screens and fences are relatively simple to construct and are typically oriented perpendicular to wind direction and located downwind from the working face. For smaller active areas, litter catch screen designs that completely enclose the working face are also very effective. The most practical designs will be portable and will be constructed of heavy-duty framing such that they can be transported and positioned using on-site equipment. There are numerous litter catch screen designs and spacings that work well (see examples on Figures 3B-1 through 3B-4). Most designs include the following elements:

- heavy duty framing
- portability with means to move and position the screens using on-site equipment
- chain link fabric or equivalent material that has a large percentage of open area with relatively small openings
- inclined slightly to provide better trapping and retention of litter
- height of 7 to 12 feet
- double rows with 40 to 80 foot spacing between rows

Note that all litter catch screens and fences should be cleaned regularly to maintain their effectiveness.

Orientation of Trenches:

For landfills located in areas that are prone to high wind, it is advantageous to use a trench fill design with trenches oriented perpendicular to prevailing wind direction (see the wind rose on your facility plot plan for prevailing wind direction). If it is not possible to orient trenches perpendicular to wind direction, then trenches should be oriented in a manner such that the working face within the trenches can be maintained as a down-wind slope.

Push Short and Minimize Handling:

Pushing short means that the refuse unloading or tipping areas are kept as close as possible to the working face of the landfill. In this manner, the distance that equipment operators will have to travel while pushing the garbage into place for cell construction and compacting is minimized. This practice will minimize the wind

exposure that the uncovered garbage will receive as it is being placed. Landfill operators and spotters should be sure that incoming vehicles are unloading as close as possible to the working face.

Cover Waste More Frequently During Periods of High Wind:

Periods of high wind may dictate that wastes be covered more frequently in order to control litter. Selective placement of small amounts of cover soil or alternative cover can effectively reduce wind dispersal of litter and can save significant amounts of time and cost when compared with litter clean up. Cover soils placed for the sole purpose of litter control do not have a minimum thickness and can therefore be placed in a manner that does not consume unnecessarily large volumes of landfill air space.

Restrict Waste Deposition / Handling During Periods of High Wind:

Not only do high wind conditions contribute to severe litter dispersal, but can also result in safety hazards for people using the landfill. Depending on landfill use, it may be necessary to implement special high-wind operating protocols or restrictions. Examples of these kinds of protocol include decreasing the size of the working face, limiting the number of vehicles that unload simultaneously, and limiting operations to areas that are best sheltered. Use of special unloading screen enclosures and alternative cover materials can also be incorporated into high-wind operating protocol. Under extreme wind conditions, it may be appropriate to close the landfill entirely.

Require Incoming Vehicles to Use Controls or Covers:

Many Wyoming landfills require that incoming vehicles be covered with a tarp or other cover such that litter and other objects do not fall out or blow out. This requirement should be posted at the landfill gate and any incoming vehicles that do not follow the policy could be surcharged a litter collection fee or could be turned around.

Conduct Frequent Litter Inspections and Clean-Up:

Preventative litter control programs will not eliminate all litter problems. For this reason, Wyoming's regulations require that landfill operators conduct and document periodic litter inspections and remove litter from on-site and off-site areas of accumulation. Litter inspections should be conducted and documented on daily or weekly logs. Depending on typical wind conditions and waste types, inspections and litter removal may need to be carried out more frequently. Regular hand pick-ups and/or vacuum trucks work well for litter removal. Litter inspection and removal efforts should focus on likely accumulation areas such as fence lines, borrow ditches, drainages, lee slopes, and areas of dense vegetation. As will be discussed under

SECTION 3. BASIC LANDFILL OPERATION

recordkeeping in Part 3J, all litter inspection and removal activities must be documented. It is best if the documentation is provided on the daily operating log (see example form in Part 3J).

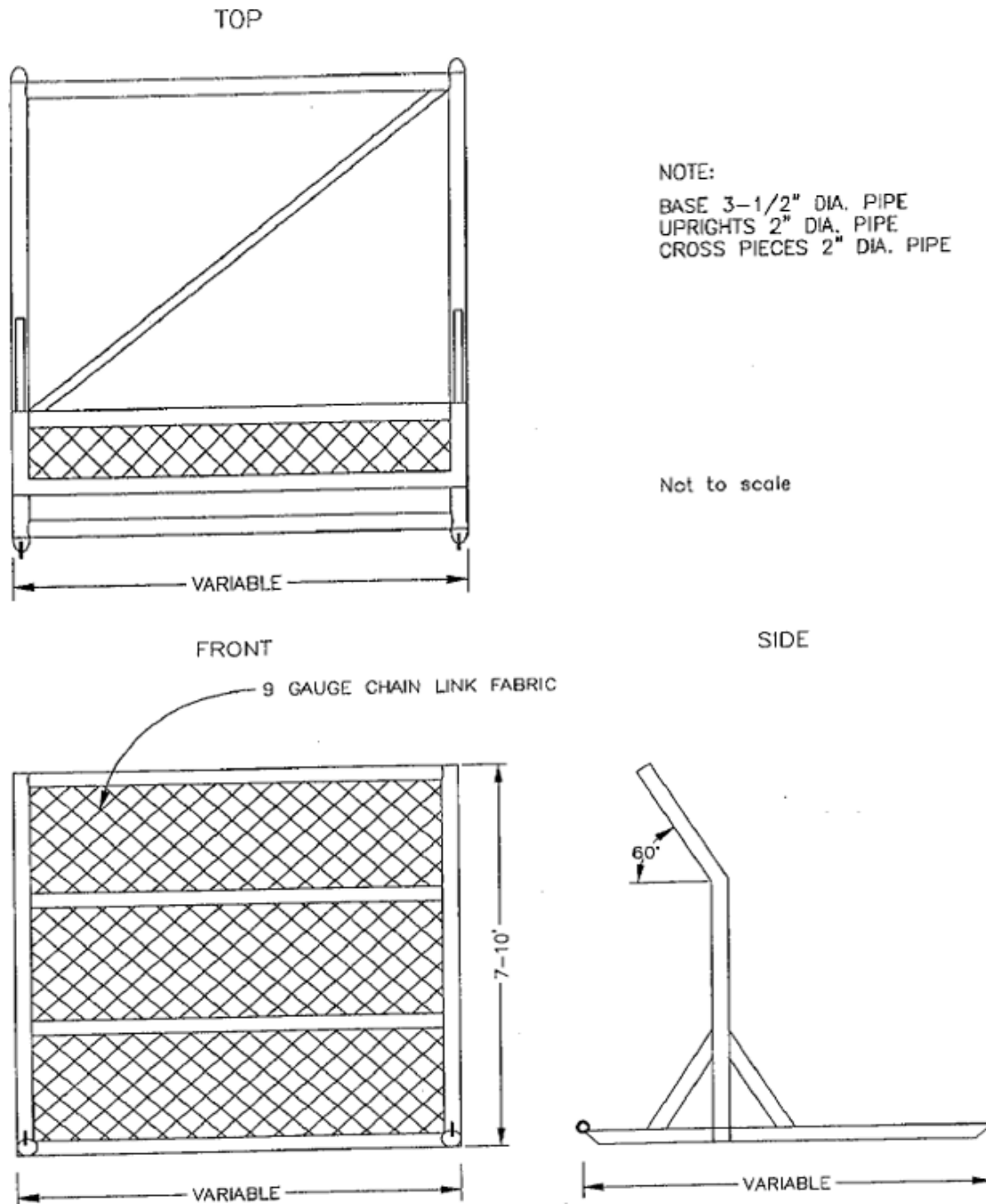


FIGURE 3B-1 :TYPICAL SKID-TYPE LITTER CATCH SCREEN,
UPRIGHT CONSTRUCTION

SECTION 3. BASIC LANDFILL OPERATION

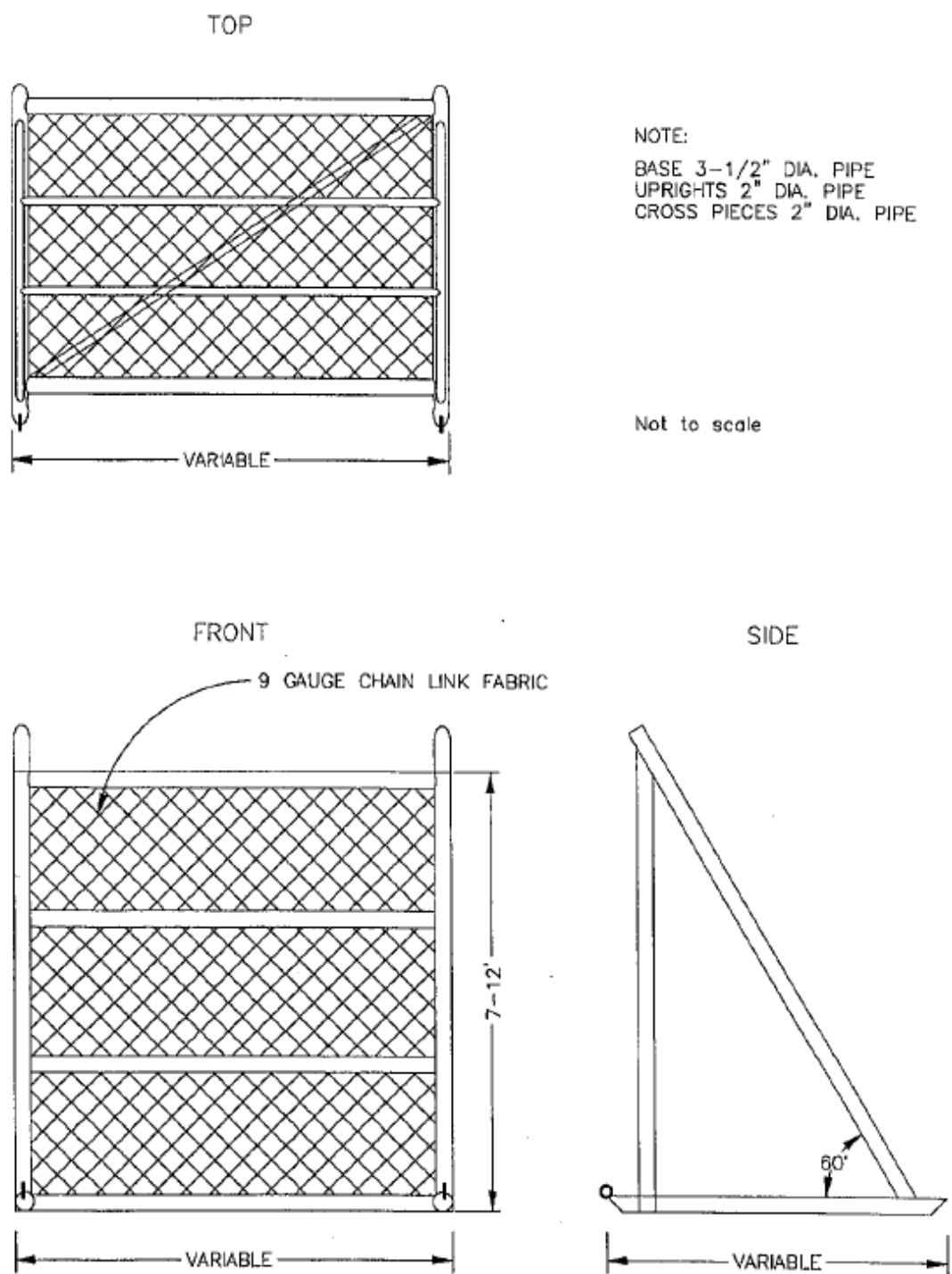
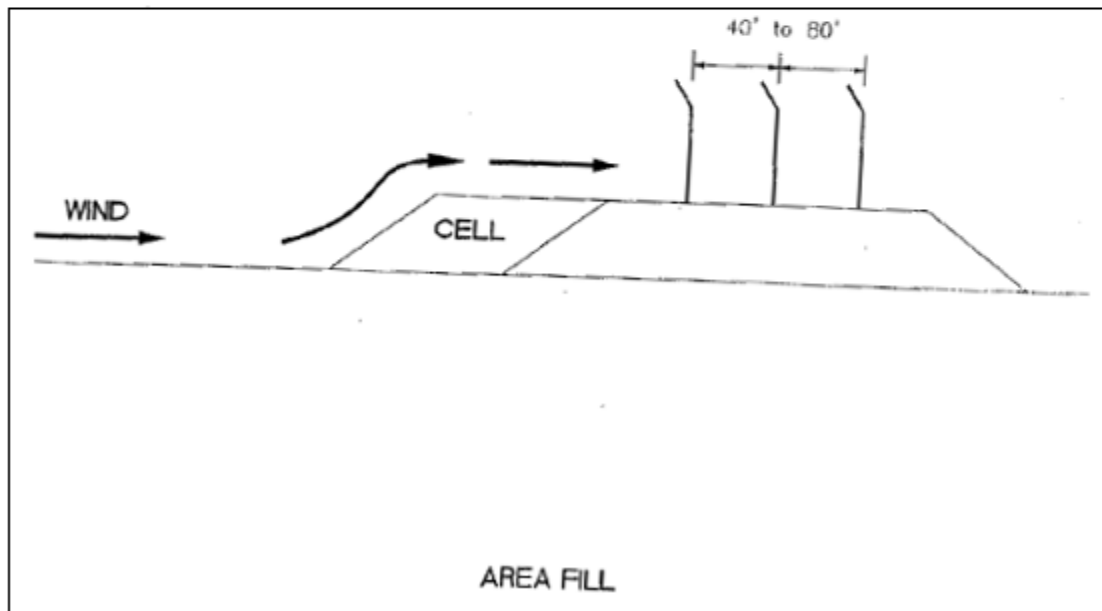
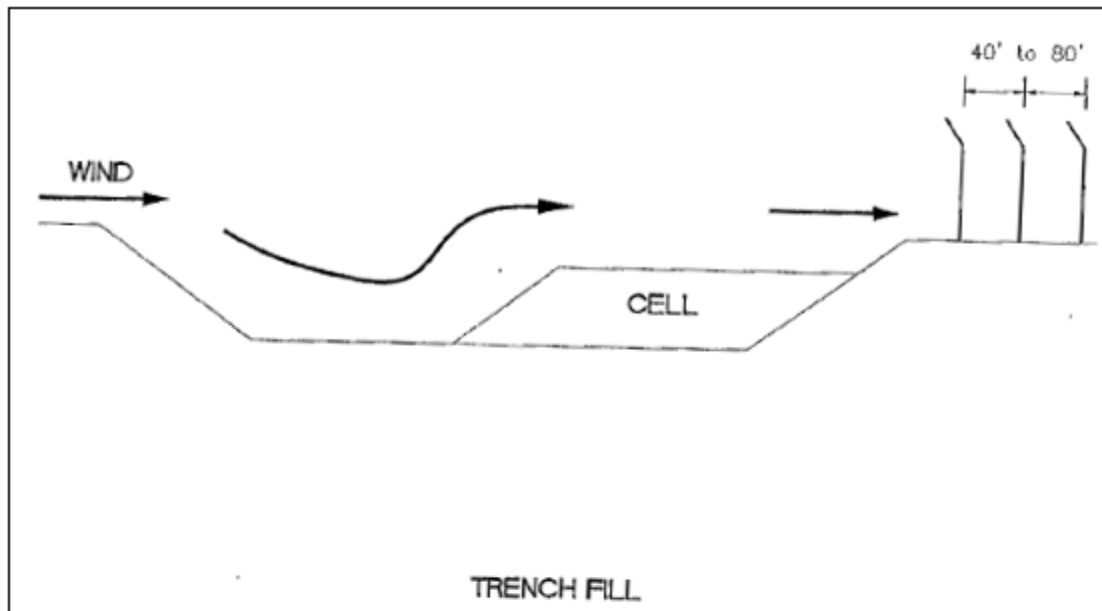


FIGURE 3B-2 :TYPICAL SKID-TYPE LITTER CATCH SCREEN,
INCLINED CONSTRUCTION

SECTION 3. BASIC LANDFILL OPERATION



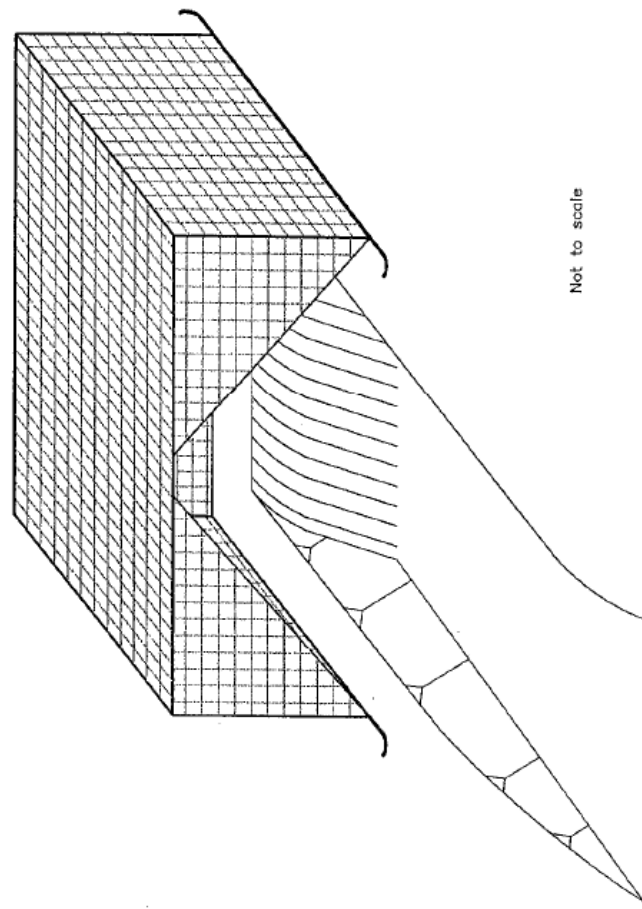


FIGURE 3B-4 :SCHEMATIC DIAGRAM OF FULL LITTER ENCLOSURE FOR SMALLER TRENCH FILL DESIGN

PART C. SELECTION AND USE OF HEAVY LANDFILL EQUIPMENT

Appropriate equipment must be used to ensure that landfill operational requirements are met and that routine landfill construction tasks are carried out in accordance with approved design parameters. Landfill operators may use outside contract equipment to perform special and/or routine landfill operations.

Ultimately, equipment selection and use are dependent on a large number of factors including fill type and sequencing, landfill size, waste types and volumes, material availability, material haul distances, operator skills, local equipment availability, and landfill economics. One of the best ways to select landfill equipment is to identify the largest and most expensive routine operating tasks, and then to match those tasks with pieces of equipment that can complete them with the greatest efficiency.

The most common types of heavy landfill equipment and primary tasks associated with each are summarized on Figure 3C-1. As Figure 3C-1 indicates, the largest and most expensive landfill operations for both trench-fill and area-fill designs will typically be waste pushing and placement, waste compaction and trimming, and waste covering. Therefore, this part focuses on the types of equipment best suited to these three (3) primary tasks. Secondary landfill construction and operating activities outside these three (3) major operational tasks are matched with various pieces of heavy equipment on Figure 3C-2.

Waste Pushing and Placement:

Waste pushing and placement are the initial steps associated with disposal in a landfill cell and require that the piece of equipment have a blade or broad bucket, and that it maintain a high level of traction under a variety of working and weather conditions. The most common types of landfill equipment used for waste pushing and placement are dozers, track loaders, and compactors. Compactors are typically preferable to other pieces of equipment for this task because they also work well for waste compaction and trimming.

Waste Compaction and Trimming:

Waste compaction and trimming is the middle step associated with disposal. This task involves repeat wheel rolling or track rolling (using special track pads) to achieve maximum waste compaction. The task also involves the use of a blade to trim off high areas and fill low areas at the surface of the compacted waste. Specially equipped dozers and compactors are best suited to this task because they can achieve relatively high levels of compaction compared to other pieces of equipment. The waste handling capacities and relative compacted densities that can be achieved with certain types of landfill equipment are listed in Tables 3C-1 and 3C-2, respectively.

Waste Covering:

Waste covering is the final step and can involve a number of different equipment tasks including excavation, hauling, placement, and compaction. For many Wyoming landfills, the process of excavating and hauling cover material to a stockpile near the active fill area or trench is performed on a batch basis and only as demand dictates. The pieces of equipment commonly used for excavating and hauling cover material include dozers, hoes, loaders, scrapers and trucks. Once the cover material has been stockpiled near the active area, it can typically be transported, placed and compacted by the same equipment used for the two earlier steps of cell construction. The daily cover stockpile should be located as close as practical to the active disposal area to save time and reduce operating costs.

Table 3C-1 Waste Handling Capacities for Different Sizes and Types of Landfill Equipment (after Bolton, 1995 and State of Kentucky, 1987).

Machine Type	Machine Weight (lbs.)	Practical Capacity* (tons/day)
Track Loader	<20,000	up to 20
Track Loader	25,000	up to 50
Track Loader	33,000	up to 130
Track Loader	45,000	up to 175
Dozer	30,000	up to 100
Dozer	40,000	up to 125
Dozer	50,000	up to 175
Dozer	80,000	up to 250
Dozer	110,000	up to 400
Compactor	32,000	up to 100
Compactor	45,000	up to 250
Compactor	70,000	up to 400
Compactor	90,000	up to 600

* Note that waste handling capacity will vary depending on waste type(s), speed of the machine, push distance, wheel and track design, machine weight, lift thickness, operator skill and numerous other factors.

Table 3C-2. Relative Waste Compaction for Different Sizes/Types of Equipment (after Bolton, 1995)

Machine Type	Machine Weight	Practical Density* (lbs./cubic yard)
Compactor	32,000	1,000 to 1,250
Compactor	45,000	1,000 to 1,250
Compactor	70,000	1,000 to 1,250
Compactor	90,000	1,150 to 1,400
Tracked Dozer / Loader	30,000	1,000 to 1,200
Tracked Dozer / Loader	40,000	1,000 to 1,150
Tracked Dozer / Loader	50,000	1,000 to 1,180
Tracked Dozer / Loader	80,000	1,040 to 1,220
Tracked Dozer / Loader	110,000	1,050 to 1,250

* Note that the density will vary depending on slope, waste type(s), speed of the machine, number of passes, wheel and track design, machine weight, lift thickness, operator skill, and numerous other factors.

1.) Dozer

The dozer is probably the most versatile piece of heavy machinery at any landfill. Although designed for pushing, a dozer can be equipped with special deep-set track pads that render acceptable compaction along with effective pushing, placement, trimming and covering capability. The dozer is also well suited to certain landfill support activities such as excavating, clearing, ripping, scarifying, road maintenance, drainage control, and grading. The dozer can also be used to handle large, bulky or heavy items such as rubble, trees, boulders and the like. Another advantage of the dozer is that it will minimize damage to access roads and unloading areas during periods of wet weather. Because they are slow and have no real hauling capacity, dozers are not well suited to transporting or placing large volumes of cover material.



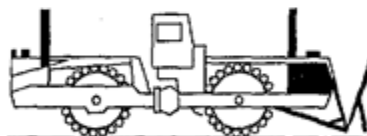
2.) Track Loader

The track loader is nearly as versatile as the dozer and, with access to various front-end attachments, can be adapted to handle a number of special tasks such as lifting, stacking, loading and hauling. The track loader is particularly well suited to trench-type designs, bale fills and smaller area fills where it can perform nearly every routine operation. Like the dozer, the track loader can be equipped with special deep-set track pads for improved shredding and compaction of waste. Because they are slow and have relatively small hauling capacities, track loaders are not well suited to operations that involve long transport distances or movement of large volumes of material over short time frames.



3.) Steel-Wheeled Compactor

The steel-wheeled compactor is a specialized machine designed mainly for placing, compacting and trimming waste during cell construction. The compactor can also place and compact cover material with adequate results. The deep-cleated wheel design of these machines offers the best weight-to-compaction ratio and is, therefore, of economic benefit to the larger landfills and landfills where the cost of air space is at a premium. A compactor will commonly work in tandem with a dozer where the dozer focuses on pushing the garbage from the unloading area to the working face. Similar to the dozer, compactors are not well suited to long or large volume hauling tasks. During wet or muddy conditions, compactor operators must take extra care to avoid damaging haul roads and unloading areas.



4.) Rubber-Tired Loader

The rubber-tired loader can perform many of the same tasks as the track loader and has the added advantages of speed and maneuverability for loading and hauling. In cases where large volumes of cover soils or other material must be excavated, hauled and/or placed, the rubber-tired loader can be very efficient and can help to reduce operating costs. As a stand-alone machine, the rubber-tired loader can experience difficulties due to limited pushing, compaction, trimming and traction capability. Instability and tire damage can also result when working in uncompacted wastes. Note that some loaders can be fitted with steel-cleated wheels, similar to those of a compactor, in order to improve compaction and traction capabilities.



FIGURE 3C-1: HEAVY EQUIPMENT FOR PRIMARY LANDFILL OPERATIONS

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1.) Scraper

Scrapers are designed specifically to excavate and haul soil materials. They are well suited for larger landfills and landfills where soil haul distances are long. Because of their weight, loaded scrapers can also be used for compaction of cover material during intermediate and/or final landfill closure. Scrapers are not recommended for compaction of wastes due to limited maneuverability and susceptibility to tire damage.



2.) Grader

Motor graders are well suited to special activities such as construction and maintenance of roadways and drainage control ditches. Graders are also well suited to reclamation and cover construction activities. Similar to other rubber-tired equipment, graders are not recommended for waste placement or compaction.



3.) Back Hoe and Track Hoe

The back hoe can be particularly helpful at landfills where light duty work is necessary on a regular basis. Examples of these types of activities include, construction of surface water controls such as drains and ditches, and light excavating, hauling and loading. Depending on the landfill design, the nature of the soil borrow areas and/or the way in which borrow operations are conducted, the use of larger track hoes may be most efficient for excavation trenches, excavating cover soil and/or loading.



4.) Dump Truck

Dump trucks will typically be used in conjunction with other pieces of equipment for hauling and stockpiling cover material at larger landfills. Dump trucks can also be used for special operations such as salvage and recycling.



5.) Water Truck

The water truck can be used for a number of routine and special activities including dust control and adjustment of soil moisture content to achieve compaction specifications during cover construction. Water trucks can also be equipped with attachments for firefighting.

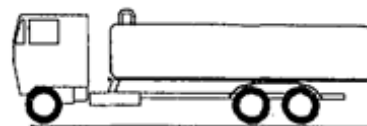


FIGURE 3C-2: HEAVY EQUIPMENT FOR LANDFILL SUPPORT OPERATIONS AND SPECIAL CONSTRUCTION WDLWEQU2

PART D. CONTROLLING ACCESS

Landfill operators must control access to prevent off-hour use, prevent disposal of unauthorized wastes, prevent disposal of waste in unauthorized areas, prevent vandalism, and ensure safe, proper use of the landfill. Access controls should be designed and constructed to discourage people and livestock from entering the facility, prevent public exposures to safety hazards and prevent unauthorized vehicular traffic. The consequences of uncontrolled access may include injury or even death.

The perimeter of all landfills must be fenced and all access roads must be equipped with gates that are to remain locked when the facility is unattended. Fencing may include chain link, barbed wire added to chain link and/or open farm-type fencing. A typical design for sheep-tight fencing is shown on Figure 3D-1. Additional fencing or other means of access control may be required within the facility interior to prevent damage/access to reclaimed areas and areas that may present public health or safety hazards. Landfill operators must ensure that the landfill is not accessible during off hours and that there are no uncontrolled entry points. Access must also be controlled during post-closure to prevent damage and vandalism to the reclaimed landfill.

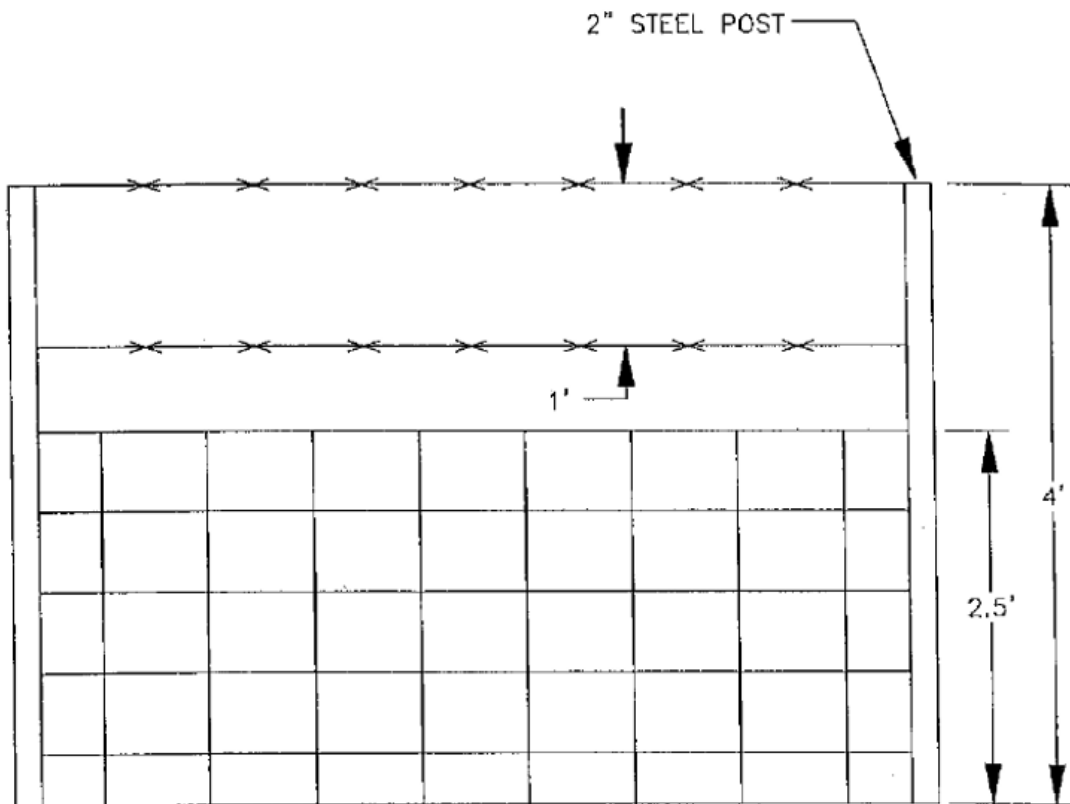


FIGURE 3D-1 :TYPICAL DESIGN OF "SHEEP-TIGHT" FENCE

PART E. SIGNING AND POSTING

To identify the landfill and to prevent dumping of illegal wastes, each facility must be posted with a sign at each point of access. The sign(s) must be easily readable, maintained in good condition and contain at a minimum the following information:

- the facility name
- the position title and phone number of the responsible person to contact in the event of an emergency
- the hours of operation
- a listing of the wastes that are prohibited from disposal at the facility
- a requirement to notify the landfill operator of any asbestos wastes
- signs to direct traffic to the proper waste management area

Additional information that may be put on the entrance sign(s) include:

- no scavenging
- salvaging occurs under the direct supervision of the landfill operator
- all loads must be covered/secured
- all trash must be bagged
- landfill could be closed during periods of high winds
- waste screening program

The more information that can be put on the entrance sign(s), the less potential for confusion when the public enters the landfill facility. However, if there is too much information on the sign and/or the text is too small or hard to read, the public will not take the time to read it and it will result in more confusion inside the facility.

Signs inside the facility should be used to direct the public to the active waste disposal areas and special waste areas. Directional signs should be highly visible and simple to follow to avoid confusion.

PART F. CONFINING THE WORKING FACE

The working face is that portion of the active trench or fill area where solid wastes are being deposited, spread and compacted prior to application of cover material (see Figure 3E-1). Landfill operators must confine the working face to the smallest practical surface area to control litter, discourage scavenging by people, birds, animals and other vectors, increase compaction efficiency, and minimize volume of daily cover material used.

The working face can be confined by controlling where and how waste unloading occurs, by pushing waste into the working face frequently, and by placing wastes such that cell volume and shape minimize cell surface area. For conventional trench-fill and

area-fill designs, waste unloading should occur as near as possible to the toe of the working face and unloaded wastes should not be allowed to advance significantly away from the toe prior to pushing and placement. For bale-fill designs, the working face should be confined by using an efficient stacking pattern where wastes are stacked as high as practical prior to advancing the next layer of bales.

The steps involved with optimizing cell shape and volume to minimize surface area are explained in detail in *The Handbook of Landfill Operations* (Bolton, 1995) and are summarized below:

- 1) Identify the cell width or trench width necessary to accommodate the average number of vehicles unloading simultaneously during high use period(s).
- 2) After cell width is selected, optimize cell volume by experimenting with cell depth and allowing cell advance (the distance of horizontal cell growth) be determined by the daily volume of compacted waste received.
- 3) Calculate the surface area of the cell and repeat the process on a trial and error basis using different cell depths until the cell configuration with the smallest surface area is identified.

In order to confine the working face, equipment operators should think in terms of building with refuse, rather than simply burying garbage. Bulky items such as tires, white wastes, rubble and other non-compactable materials should be placed at the bottom of the cell. Compactable waste should be used to finish the top and exposed sides of the cell. This practice will increase the ability of the operator to construct tightly compacted and neatly trimmed cells that have well confined working faces.

SECTION 3. BASIC LANDFILL OPERATION

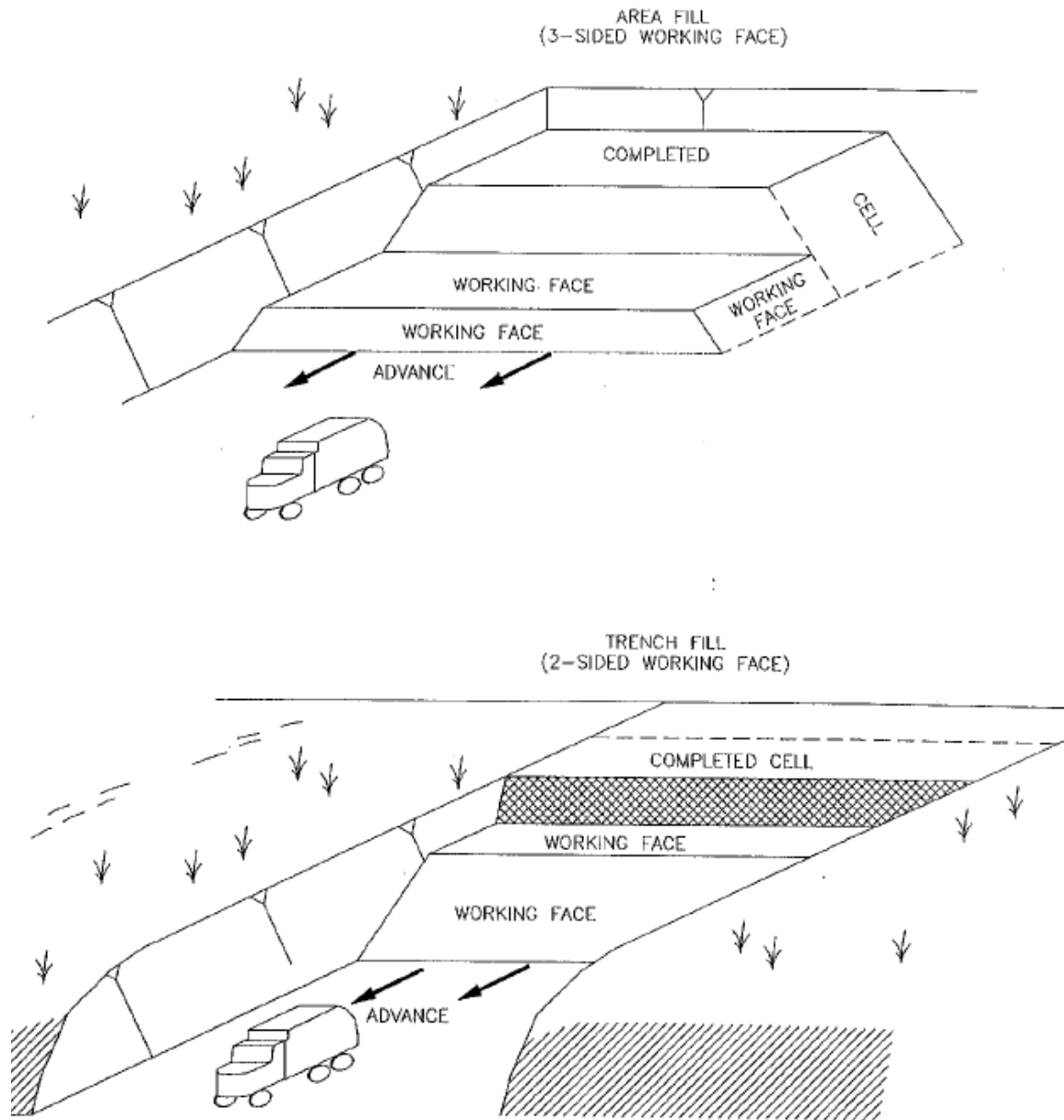


FIGURE 3E-1 THE WORKING FACE OF ACTIVE AREA FILL AND TRENCH FILL DISPOSAL AREAS

PART G. OPERATION OF SPECIALTY WASTE AREAS

Landfill operators must maintain adequate provisions to handle and dispose of specialty wastes so that they do not create a public nuisance, fire hazard, health hazard or detriment to the environment. Specialty wastes can include any wastes that require special handling and/or disposal procedures, or that are routinely removed for salvage or recycling.

Note: Landfill operators must not confuse specialty wastes with special wastes. Special wastes are defined in Chapter 8 of Wyoming's Solid Waste Rules and Regulations and are limited to scrap tires, asbestos-containing wastes, petroleum contaminated soils, and petroleum storage tanks. Special wastes are discussed in Part H of this Section.

It is better to accept specialty wastes at the landfill, if possible, than to turn them away and find them illegally dumped. To accomplish adequate specialty waste management, signs should be used to direct traffic to the specialty waste disposal area(s) and should be worded to prevent disposal of other mixed wastes in these areas. Disposal of specialty waste(s) should be restricted to the smallest practical area. All-weather access roads should be constructed to each specialty waste disposal area and storm water run-on should be diverted around the disposal area. The site attendant should screen specialty wastes and direct traffic to the correct disposal area. Proper management and disposal operations for common types of specialty wastes are presented below.

Appliances (White Goods):

White goods must be accompanied with documentation verifying that the refrigerants (CFCs) have been properly removed. If documentation is not attached, segregate and hire an outside contractor to remove the refrigerants, prior to disposal or salvage. Appliances can be stockpiled for recycling, or crushed and disposed. Because they are heavy and bulky, they should be placed near the bottom of the cell.

Scrap Metal and Car Bodies:

If possible, these materials should be stockpiled and sold to outside scrap contractors for recycling. If necessary, these materials can be disposed in a manner similar to white goods. All liquids need to be removed from automobiles, lawn and garden equipment, etc. prior to disposal.

Construction and Demolition Debris:

Construction and demolition debris may be disposed of along with household refuse or may be managed separately in a special trench or fill area. In certain cases, these wastes may be clean fill and may be managed as specified below. Landfill operators should contact the DEQ if questions or uncertainty regarding proper management of construction and demolition debris arise.

In Chapter 1 of the Solid Waste Rules and Regulations, clean fill is identified as material consisting solely of uncontaminated natural soil and rock, hardened asphalt rubble, bricks, and concrete rubble. Many landfills accept this type of material for disposal; however, this material does not require a permit for disposal provided it is managed in an environmentally sound manner. Therefore, landfill operators may elect not to accept such material in order to save landfill space.

Clean fill may be disposed in a landfill along with household refuse or can be managed separately in a special trench or fill area. In many cases, these wastes can be used as daily cover material for tires or other wastes. They can also be used to stabilize portions of a landfill cell as it is being constructed and can be used to stabilize areas that may be susceptible to erosion.

Used Motor Oil:

Used motor oil can be accepted from do-it-yourself oil changers but cannot be accepted from businesses or gas stations. If possible, the used oil should be recycled or can be burned in an oil-fired space heater with a maximum capacity of 0.5 million Btu/hour. Used oil should be stored only in an approved and labeled barrel or tank (label must say Used Oil). Oil spill containment devices should be used for above-ground storage tanks. Contingency plans for cleaning up and reporting a spill should be in place. Note that a spill of any hazardous substance that threatens or has potential to threaten waters of the State must be reported to DEQ/Water Quality Division immediately.

Clean Wood, Brush, Tree Trimmings, etc.:

Preferably, these materials will be stockpiled for chipping or shredding as compost and landscaping material. Alternatively, they can be stockpiled for burning, provided a permit from DEQ/Air Quality Division is obtained. Only clean wood, tree trimmings, brush, agricultural wastes, silvicultural wastes, land clearing wastes, diseased trees and debris from emergency cleanup operations are allowed in the burn pile. Clean wood means untreated wood which has not been painted, stained or sealed. Clean wood does not include treated railroad ties, treated lumber, treated posts, paper, or construction/demolition wastes containing non-wood materials.

Large Animals:

Large animals must be covered with a minimum of 6" of soil cover material at the end of each day to prevent scavenging and spread of disease by animals, insects and other vectors. Large animals may be disposed in a separate dead animal pit or in the active waste disposal trench or fill area. For aesthetic reasons, disposal of large animals in a separate area is typically favorable to disposal in the general refuse area.

Ashes:

Ashes should be stored in a separate area for sufficient time to ensure they are fully cooled prior to disposal. New uses may be approved by the DEQ including daily cover and surfacing on access roads.

Lead Acid Batteries:

No more than 1,200 used lead acid batteries can be stored on site at any one time for recycling. Used batteries should be stockpiled in an upright, non-leaking position on a pallet with a plastic liner underneath. Batteries should not be stacked more than 2 batteries high to prevent breakage and spillage of contents.

PART H. OPERATION OF SPECIAL WASTE AREAS

Special wastes are those listed in Chapter 8 of the Solid Waste Rules. Special wastes include scrap tires, asbestos-containing wastes, petroleum contaminated soils, and petroleum storage tanks. Some general operating requirements are included below, but operators need to refer to Chapter 8 for detailed requirements.

Scrap Tires:

In areas used only for scrap tire disposal, scrap tires must be completely covered with at least six (6) inches of soil every ninety (90) days or when 5,000 tires have been disposed, whichever comes first. Scrap tires may be disposed with household solid waste, disposed in a separate trench, or stockpiled for shredding or recycling. If buried whole, tires should be placed at the bottom of the cell and covered with broken concrete, asphalt or other heavy wastes to prevent them from floating up. Common problems that result with lengthy storage of scrap tires are that they provide habitat for vectors such as mosquitos and rodents and they can be a fire hazard. Operators should be aware of these potential problems and should remove or dispose of accumulated scrap tires frequently.

Asbestos Containing Solid Waste:

When dry, an asbestos containing material (ACM) is considered friable if it can be crumbled, pulverized, or reduced to powder by hand pressure. If it can't, it's considered non-friable ACM.

Non-friable Asbestos Containing Waste:

Non-friable asbestos wastes must be covered with a minimum of six (6) inches of acceptable cover material prior to compaction. The wastes must be covered immediately if the wastes are disposed in a unit that is not subject to Chapter 8 access restrictions. The waste must be covered within twelve (12) hours of receipt, if the wastes are disposed in a unit that is subject to Chapter 8 access restrictions. Non-friable asbestos wastes must be disposed in a manner that minimizes any increase in friability of the wastes, particularly the friability of any exposed edges.

Friable Asbestos Containing Waste:

Landfills must be specifically permitted to dispose of friable asbestos containing waste. Refer to Chapter 8 to find detailed requirements for the management of friable asbestos containing waste. General requirements include, but are not limited to:

- additional location standards
- design and construction standards that include construction of units in an area of the landfill that is physically isolated from the general public
- fencing and warning signs to protect the public
- operating standards that prohibit public access within 200 feet and specific management and cover requirements

Petroleum-Contaminated Soil:

Petroleum-contaminated soil (PCS) requirements in Chapter 8 include specific location, design and operating standards. Many of these standards apply to facilities that treat PCS for reuse as fill. PCS does not need to be treated to clean fill concentration levels in order to be disposed or used as daily cover at a permitted MSW landfill. The PCS must be non-hazardous and pass the SW-846 Test Method 9095B, Paint Filter Liquids Test, in simple terms, it must be dry. PCS may not be used as intermediate or final cover.

Petroleum Storage Tanks:

Chapter 8 includes location, design, and operating standards for facilities that manage petroleum storage tanks (PSTs). A PST is any underground or aboveground

storage tank that has been taken out of service and which contained any petroleum substance, including but not limited to motor fuels, jet fuels, distillate fuel oils, residual fuel oils, lubricants, petroleum solvents, and used oils. Decommissioning is required to permanently close a PST regulated under Chapter 17 of the Water Quality Rules and Regulations. PSTs not specifically regulated under Chapter 17 of the Water Quality Rules and Regulations should also be decommissioned to protect human health and the environment. The objective of decommissioning is to remove all liquids and accumulated sludges. The DEQ recommends that properly decommissioned steel tanks be recycled. However, tanks subject to Water Quality Chapter 17 decommissioning requirements and other PSTs (and other containers) that are empty by definition may be disposed in a MSW landfill.

RCRA defines an empty container as:

1. RCRA Empty determination for a container Option #1:

All wastes have been removed that can be removed using common practices to remove materials, e.g. pouring, pumping, and aspirating, and

No more than 2.5 cm (1 inch) of residue remains on the bottom of the container. (Note that some drum pumps may not meet these standards.)

Or...

2. RCRA Empty determination for a container Option #2:

All wastes have been removed that can be removed using common practices to remove materials, eg. pouring, pumping, and aspirating, and

For containers ≤ 119 gallons in size (non-bulk containers): No more than 3% by weight of the total capacity of the container remains in the container or inner liner, or

For containers > 119 gallons in size (bulk containers): No more than 0.3% by weight of the total capacity of the container remains in the container or inner liner.

PART I. WASTE SCREENING & CONTROL OF PROHIBITED WASTES

Landfill operators must randomly screen incoming wastes to prevent disposal of PCB wastes and hazardous wastes, prevent disposal of liquid wastes, and identify and properly dispose of authorized special waste(s). This practice is necessary to provide safe landfill operation, to reduce the risk of fire and emergency, and to minimize the risk of groundwater contamination. Waste screening is also beneficial to identify materials that can be recycled or reused (if applicable) and to maximize landfill efficiency.

Check with the DEQ for any available guidance on waste screening. Load checks should be documented in the daily operating log (see Example 3H-1). A random load check program offers a quick mechanism for landfill operators to inspect and document incoming wastes. At a minimum, your random waste screening program and load check program should be adequate to identify:

- PCB wastes
- potentially hazardous wastes generated by businesses
- used oil, antifreeze and other liquid wastes
- friable and non-friable asbestos wastes
- asbestos-containing wastes
- petroleum contaminated soils (PCS)
- petroleum storage tank wastes

PART J. RECORDKEEPING

Written records must be generated by the landfill operator and maintained at an approved location so that DEQ inspectors can verify that the landfill is being operated in accordance with State Regulations and the facility operating permit. Records that must be generated and maintained at the facility for at least three (3) years include:

- log of litter collection
- waste sold or salvaged
- types and disposition of special wastes
- problems that caused operations to cease

Records that must be generated and maintained through the end of the post-closure period include:

- litter collection logs
- any permit application prepared under this chapter
- if not contained in the permit application, any location restriction demonstration which is required
- log of random inspections or other screening activities for regulated hazardous wastes and PCB wastes specifying the date, time, and name(s) of the inspection personnel and any notifications to the Administrator
- records of training of landfill operators to detect hazardous wastes and PCB wastes
- monitoring results, and any notification or remediation plans
- as-built specifications for disposal units, including liners, caps, and leachate collection systems, with their dates of construction, location, length, width and depth;
- dates when trenches and units are completed, and their contents

SECTION 3. BASIC LANDFILL OPERATION

- closure and post-closure plans, if not already contained in the permit application, and any monitoring, testing, or analytical data required in the plans
- any cost estimates and financial assurance documentation
- if not contained in the permit application, any performance based design demonstration
- dates when reclamation activities take place
- copies of written correspondence with the DEQ

To document many of these records, landfill operators should develop and maintain a daily landfill operating log. The format of the daily operating log should be simple to complete but should include enough detail that any unusual operating circumstances and problems can be adequately documented. A sample daily operating log form is included as Example 3H-1.

EXAMPLE 3H-1. DAILY LANDFILL OPERATING LOG

DATE		WEATHER CONDITIONS					
		am	pm				

OPERATING PERSONNEL							
1.	2.	3.	4.				

LOG OF LITTER COLLECTION							
Area Inspected:		Litter Collection Performed?	Y	N	Comments:		
Area Inspected:		Litter Collection Performed?	Y	N	Comments:		

LOG OF WASTE COMPACTING AND COVERING							
Disposal Area:		Wastes Compacted?	Y	N	Wastes Covered?	Y	N
Disposal Area:		Wastes Compacted?	Y	N	Wastes Covered?	Y	N
Disposal Area:		Wastes Compacted?	Y	N	Wastes Covered?	Y	N

LOG OF SPECIAL WASTES RECEIVED							
Waste Type:		Source:		Weight or Volume:		Consistency:	
Location of Special Waste Disposal:		Analytical Data Attached?	Y	N	Comments:		

LOG OF SOLD, SALVAGED & RECYCLED WASTES							
Waste Type:		Weight or Volume:		Destination:		Shipping Bill Attached?	Y
							N

LOG OF PROBLEMS CAUSING LANDFILL OPERATIONS TO STOP							
Problem Description:		Emergency?	Y	N	Time of Operations Stop:		
Actions Taken:					Time Operations Resumed:		

LOG OF RANDOM LOAD CHECKS AND SCREENING FOR HAZARDOUS WASTE / PCB WASTE							
Vehicle make/type:		Plate Number:		Waste(s) in load:			
Evidence of Hazardous Waste or PCBs?	Y	N	Actions Taken:				

LOG OF INTERMEDIATE RECLAMATION ACTIVITIES							
Intermediate Reclamation Underway?	Y	N	Location:		Dimensions of Reclaimed Area:		
Intermediate Reclamation Being Documented on Fill Sequence Map?	Y	N					

PART K. FIRE PROTECTION MEASURES

Fire lanes are necessary to allow firefighting equipment access to the active disposal area, to minimize the potential for an on-site fire to spread off site, and to prevent off-site fires from spreading to the landfill. Municipal landfill operators must establish and maintain fire lanes around the active disposal area(s) or within the perimeter fence. Fire lanes must be at least 10 feet wide, must be kept traffic-ready and must be kept clear of obstructions and combustible material. Information regarding specifications and layout of fire lanes is discussed in Section 2, Part B of this Workbook.

In addition to establishing and maintaining fire lanes, landfill operators must also have serviceable fire extinguishers on site and, depending on the location, must maintain access to some form of communication with the local fire department. If possible, the landfill attendant should have access to a telephone or radio that can be used to call the fire department.

Although not required under current regulations, additional fire protection measures that should be considered, especially at larger landfills, include development of an emergency response plan.

An emergency at a landfill will typically be a fire, accident or hazardous materials incident. Therefore, the minimum content of an emergency response plan should be:

- Fire Department and Ambulance telephone numbers
- chain of command
- notifications that must be made (solid waste manager, DEQ, land owners, etc.)
- location of and route to nearest hospital or emergency clinic
- location of primary and secondary equipment staging areas
- incident report form
- practice drill program to ensure that the plan is carried out effectively in the event of a real emergency

PART L. CONTROLLING AESTHETICS

Landfill operators must control aesthetics (the appearance of the facility) to maintain good public relations, to prevent nuisances, and to prevent certain types of health and safety hazards. One of the most important aesthetic controls that must be exercised is the litter control program (discussed in detail in Part B of this section). In addition to controlling litter, landfill operators must control dust, odors and vectors. Landfill operators should also be sensitive to the visual appearance of the landfill.

When formulating aesthetic controls it is important to consider how your landfill is designed and operated. Some important landfill characteristics that should be

considered with respect to development and implementation of aesthetic controls include:

- visibility of landfill to neighbors, public lands and outside roadways
- periods and types of high landfill use/activity (daily, seasonally)
- the types and volumes of wastes received and the characteristics of the wastes
- layout and location of waste management areas
- layout, location and methods of soil/cover material handling
- layout and location of haul roads and unloading/tipping areas
- prevailing wind direction, speed and other weather conditions
- proximity of the landfill to animal and insect habitat such as water bodies, forest, heavy vegetation, residential areas, etc.
- the type of animals and insects in your area that are most likely to be vectors (a vector is any carrier capable of transmitting a pathogen from one organism to another; they include people, animals, birds and insects)

Methods to Improve Visual Aesthetics

- exercise preventative litter controls and conduct frequent litter collection (reference Part B of this Section)
- use natural topographic features as visual screens
- use natural and/or imported vegetation as visual screens
- use of access control fencing, material stockpiles, and other features of landfill construction and operation as visual screens

Methods to Control Dust

- determine what time of day is best for certain operations
- restrict use and traffic to certain areas and/or roads during periods of high wind
- use water truck to control dust on haul/access roads and during handling of soil/cover material
- if necessary, close the landfill during periods of extreme wind

Methods to Control Odor

- use cover material more frequently to control odors from putrescible wastes such as large volumes of food waste and dead animals
- manage odorous wastes in smaller, isolated trenches or fill areas that offer advantages with regard to how the odors are distributed and how frequently cover material can be applied

Methods to Control Vectors

- avoid creating preferable vector habitat with refuse (examples of vector habitat include snakes in scrap metal piles, mosquitos in scrap tires and birds in the dead animal pit)
- use cover material more frequently if necessary, particularly for dead animals, medical wastes and other food sources
- use improved fencing for larger animals such as dogs and bears
- use sonic devices and/or netting for birds
- consider removal and relocation of vectors

PART M. SALVAGING AND RECYCLING PRACTICES:

Controlled salvage and recycling operations at landfills is encouraged because they can conserve landfill space and thereby reduce the need for new landfills and expansion of existing landfills. By segregating and periodically removing certain waste materials, salvage and recycling practices can also be of benefit with respect to landfill construction and operation, and can provide added protection of groundwater.

The DEQ may have guidance available for operators considering development of a landfill salvage and recycling program. If landfill managers and operators elect to establish recycling or salvage operations at the landfill, they are encouraged to develop and follow a salvage and recycling plan. Key elements of such a plan would include:

- identification of the waste types and sources that are eligible for the program
- characteristics of the waste that must be maintained
- methods and practices that are to be followed when segregating, stockpiling, loading and shipping materials
- identification of landfill personnel, outside contractors and agents who are authorized to conduct the salvage and recycling
- markets and destination of waste
- containerization, packaging, transport and documentation requirements
- personnel training requirements
- landfill design relative to stockpile locations, access roads, and public safety

*Note: Salvaging is not the same as scavenging. Wyoming's current regulations **prohibit scavenging**. Scavenging is defined as the removal by persons other than the landfill operator or his or her agent of solid wastes from any solid waste management facility for the purpose of reuse. Scavenging is prohibited because it is **dangerous** and can lead to injury or death and because it can interfere with landfill operations and employee duties.*

PART N. TOPSOIL HANDLING

To ensure that an adequate supply of topsoil is available for use during reclamation activities at the landfill facility, the following procedures should be followed:

1. Topsoil from all disturbed areas must first be removed and stockpiled.
2. The full depth of topsoil should be removed. If unsure of the depth of the existing topsoil, at least six (6) inches should be removed.
3. Topsoil stockpiles should be located in an area where it will not be disturbed during facility operations and must be identified by signs to ensure topsoil is not used for other purposes.
4. Topsoil stockpiles must be vegetated as required for stabilization from wind/water erosion.

Methods for protecting topsoil in stockpiles include:

- orienting stockpile parallel to wind
- using fly ash or asphalt millings to cover stockpile
- keeping stockpile low
- establishing vegetation
- using mulch

Topsoil cannot be removed from the facility site without written authorization from DEQ.

PART O. INTERMEDIATE AND FINAL COVER

At various stages of landfill development, it will be necessary to install intermediate cover and construct final cover over disposal areas that have reached capacity. These procedures are necessary to reduce the potential for leachate generation and infiltration of rainwater and snowmelt in fill areas that have ceased receipt of waste or that will not receive waste for extended periods.

Intermediate Cover:

Installation of intermediate cover material is required for any landfilled trench or area that will not be active for a period longer than 180 days. Intermediate cover material is installed over the top of daily cover and consists of 12 inches of soil the daily cover already in place. Intermediate cover is illustrated on Figure 3L-1.

Final Cover:

To minimize infiltration, leachate generation, and threats to groundwater, final cover needs to be installed no later than thirty (30) days after a disposal unit reaches capacity and must be completed within 180 days. Figure 3L-2 illustrates this procedure for a trench fill landfill and Figure 3L-3 illustrates this procedure for an area fill landfill. The specific construction steps involved with installing final cover will be outlined in your approved application and closure plan. The minimum final cover will typically consist of a prepared subgrade, a minimum of two (2) feet of compacted soil material, frost protection, and six (6) inches of topsoil supporting specific types of vegetation (see Figure 3L-4). Note that frost protection is not illustrated in Figure 3L-4.

The permeability of the 2-foot compacted soil layer must be less than or equal to the landfill bottom liner or subsoils, and that the maximum allowable permeability for any municipal landfill cover is **1×10^{-5} cm/sec, regardless of subsoils permeability.** Your approved application may specify a lower permeability (see Section 7 of this Workbook for further discussion). In order to achieve these minimum specifications, it can be very important to use only select cover soil materials that can be installed to achieve the proper moisture content and compacted density (compacted soil density will typically be measured in the field to verify that the permeability specification is achieved). Use of select soil material for final cover construction is particularly important for areas where soils tend to contain large percentages of sand and/or gravel. In such cases, it is very important that the landfill operators or contractors who install final cover understand the soil characteristics, construction steps, and testing procedures necessary to verify that the approved cover permeability specification is achieved during phased reclamation.

It is very important to document and maintain records that final cover was installed according to the approved plan. This information will be needed because a Wyoming registered professional engineer must certify that facility and unit closure have been completed in accordance with the approved closure plan.

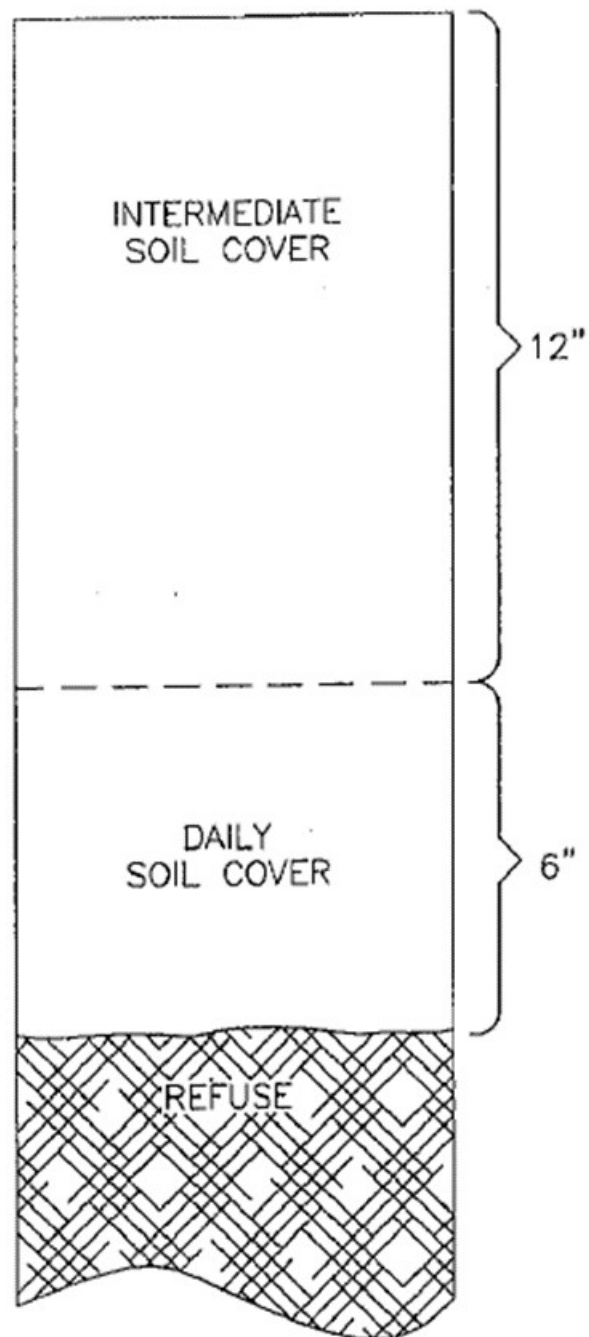


Figure 3L-1: Properly installed Cover

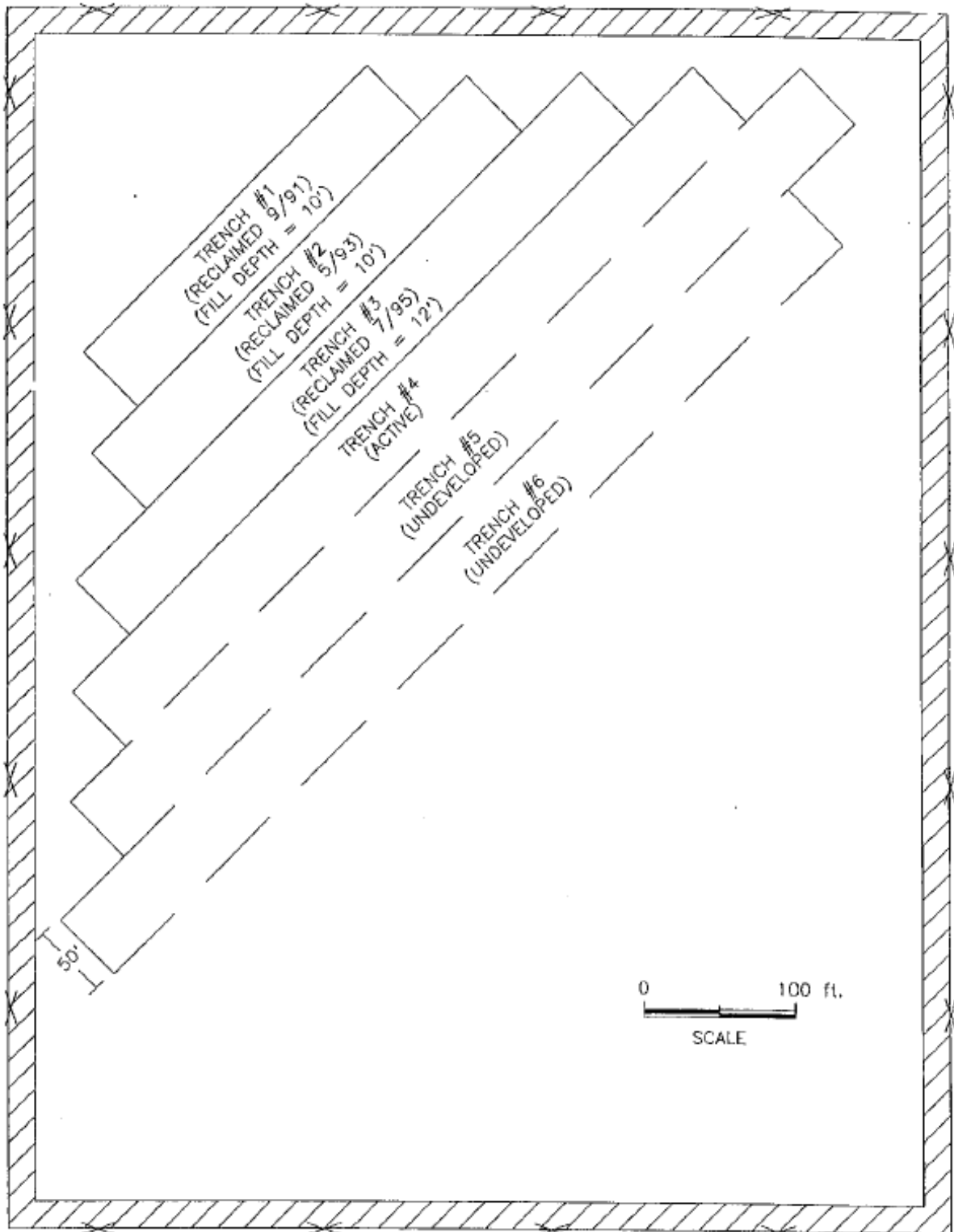


FIGURE 3L-2 :FILL SEQUENCE AND PHASED RECLAMATION PLAN

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SECTION 3. BASIC LANDFILL OPERATION

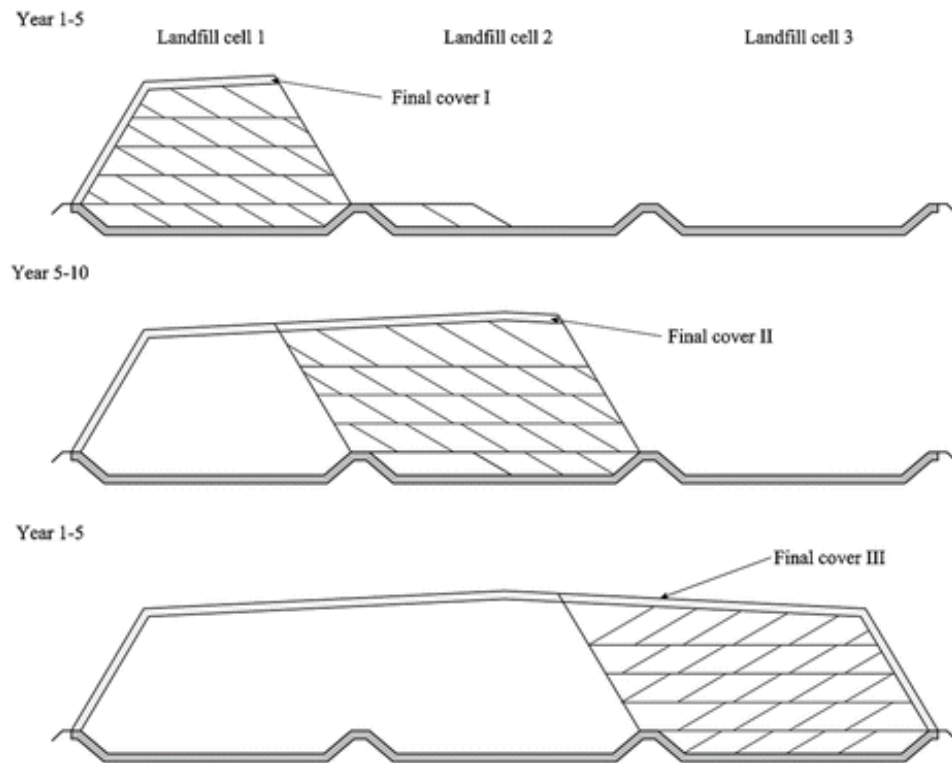


Figure 3L-3: Phased final cover installation for an area fill landfill

SECTION 3. BASIC LANDFILL OPERATION

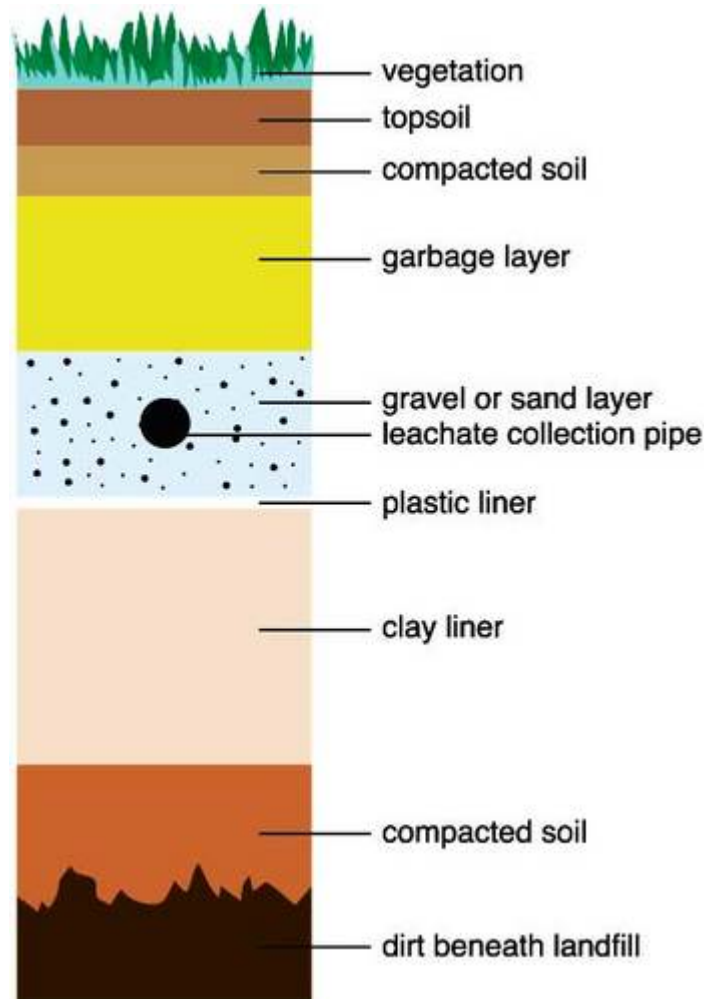


Figure 3L-4

SECTION 4

MUNICIPAL SOLID WASTE LANDFILL PERMITTING

SECTION 4

MUNICIPAL SOLID WASTE LANDFILL PERMITTING

TRAINING OBJECTIVES:

- 1) To familiarize landfill managers with the general requirements for solid waste management permits.
- 2) To provide landfill managers with an understanding of the permitting process, including the role of public involvement.
- 3) To help landfill managers identify those location standards that may apply to their existing or proposed landfill facilities.
- 4) To explain permit variance procedures and assist landfill managers with identification of specific areas where variances may be necessary.
- 5) To explain major permit amendment procedures and identify those changes that require major permit amendments to the landfill plan.

PART A. GENERAL REQUIREMENTS

Landfills in the State of Wyoming are permitted through the Wyoming Department of Environmental Quality, Solid and Hazardous Waste Division (DEQ). The permitting process involves the public and is thorough in an effort to insure that the DEQ is provided with all the information necessary to reach a sound permit decision. Permits are based on an approved plan that describes the specifics of the location, design, construction, monitoring, closure and post-closure of the landfill facility.

Permits Are Required from DEQ:

- to operate and continue to operate a landfill
- to close a landfill facility
- to obtain approval for a major amendment to a landfill's operating plan

All Permit Applications:

- must contain a completed permit application form (see Guideline #3)

SECTION 4. PERMITTING

- are to be bound in 3-ring loose leaf binders
- should contain sequentially numbered pages, each identifying the name and SHWD File number and the preparation or revision date
- should contain a Table of Contents, List of Figures, and List of Appendices

Permit Application Forms are Signed by:

- the professional engineer who either prepared or supervised development of the permit application (Wyoming P.E. stamp required)
- the land owner / lien holder
- the applicant or duly assigned representative(s)
- a notary public
- portions of the application that require geological services or work must be stamped and signed by a Wyoming registered professional geologist

New Facilities:

The key to development and permitting of a new facility is planning ahead. Even before permit preparation begins, a significant amount of time and effort is involved in just evaluating various site options, receiving public feedback, selecting the optimum location, and securing the proposed site. For this reason, the DEQ suggests that initial preparations for development of a new facility begin at least five (5) years before current landfill capacity is expected to expire.

Early public involvement in the site selection process is always advisable, even though it is not actually required by regulation until the point in the process at which the new permit application is submitted and deemed complete. Public input at an early stage is helpful to avoid incurring adverse public response which can lead to permitting delays and/or project abandonment.

The permitting process for a new facility also typically involves site investigation work in order to provide the specific information required concerning site soils, geology and hydrology. Since site investigations and development of site plans can be an expensive process, the DEQ recommends scheduling a pre-application inspection with DEQ personnel to evaluate site suitability. That way, expenses are not incurred for sites that do not meet location standards (see Section 4C).

New Operating Permits:

- should be planned starting at least five (5) years before existing facilities reach capacity

SECTION 4. PERMITTING

- should be compiled and submitted at least 12 months before the proposed construction date to avoid permitting delays
- will be “lifetime” permits issued for the life of the facility, through closure, not to exceed twenty-five (25) years

New Permit Applications Contain Information Concerning:

- general facility information
- location standards
- regional geology and hydrology
- site specific geology and hydrology
- facility design, construction and operation
- environmental monitoring
- recordkeeping
- reporting
- closure/post-closure plans
- financial assurance
- corrective action plans, if necessary
- transfer, treatment and storage facility standards, if applicable
- special waste, if applicable
- commercial solid waste facility standards, if applicable
- supporting documentation (maps, cross-sections, etc.)

Renewal Permits:

Once a landfill has received its initial permit, subsequent permits issued by the DEQ are called renewal permits. These permits require submission of a renewal permit application containing specific information addressing the next phase of landfill development covered during the next permit term.

- for landfills without a lifetime permit, a renewal permit application must be submitted 12 months prior to the existing permit’s expiration date
- for landfills with a lifetime permit, a renewal permit application must be submitted no later than 3 years prior to the permit’s expiration date
- will be “lifetime” permits issued for the life of the facility through closure, not to exceed 25 years

Renewal Permit Applications are Required to Contain:

- a compilation of previous permit application materials and supplemental information updated and revised as necessary to document facility operations and activities carried out during the last permit term
- a copy of the approved permit or renewal permit application or revisions to the previous application if the revised and updated pages and drawings are appropriately numbered and dated to be incorporated into the previous permit document
- any necessary plan revisions for the upcoming permit renewal period and any requests for approval of amendments
- detailed construction and operation specifications for the upcoming permit period, if such specifications were not included in an approved facility permit application

Closure Permits:

When a facility is reaching capacity and will no longer be accepting wastes, a closure permit application must be prepared that provides details of the activities necessary for proper closure, if not already provided, and post-closure care.

- are due no later than 12 months prior to the date the facility is anticipated to cease receipt of waste
- are due within 30 days after a continuous 9-month period of non-receipt of waste (unanticipated closure)
- are issued for a period including the time required to complete closure activities plus the length of the post-closure period (30-year minimum)

Closure Permit Applications Contain Information Concerning:

- permit application form
- general information
- regional geology and hydrology
- site specific geology and hydrology
- facility design and construction
- environmental monitoring
- recordkeeping
- reporting
- financial assurance
- corrective action plans, if necessary
- transfer, treatment and storage facility standards, if applicable
- special waste, if applicable

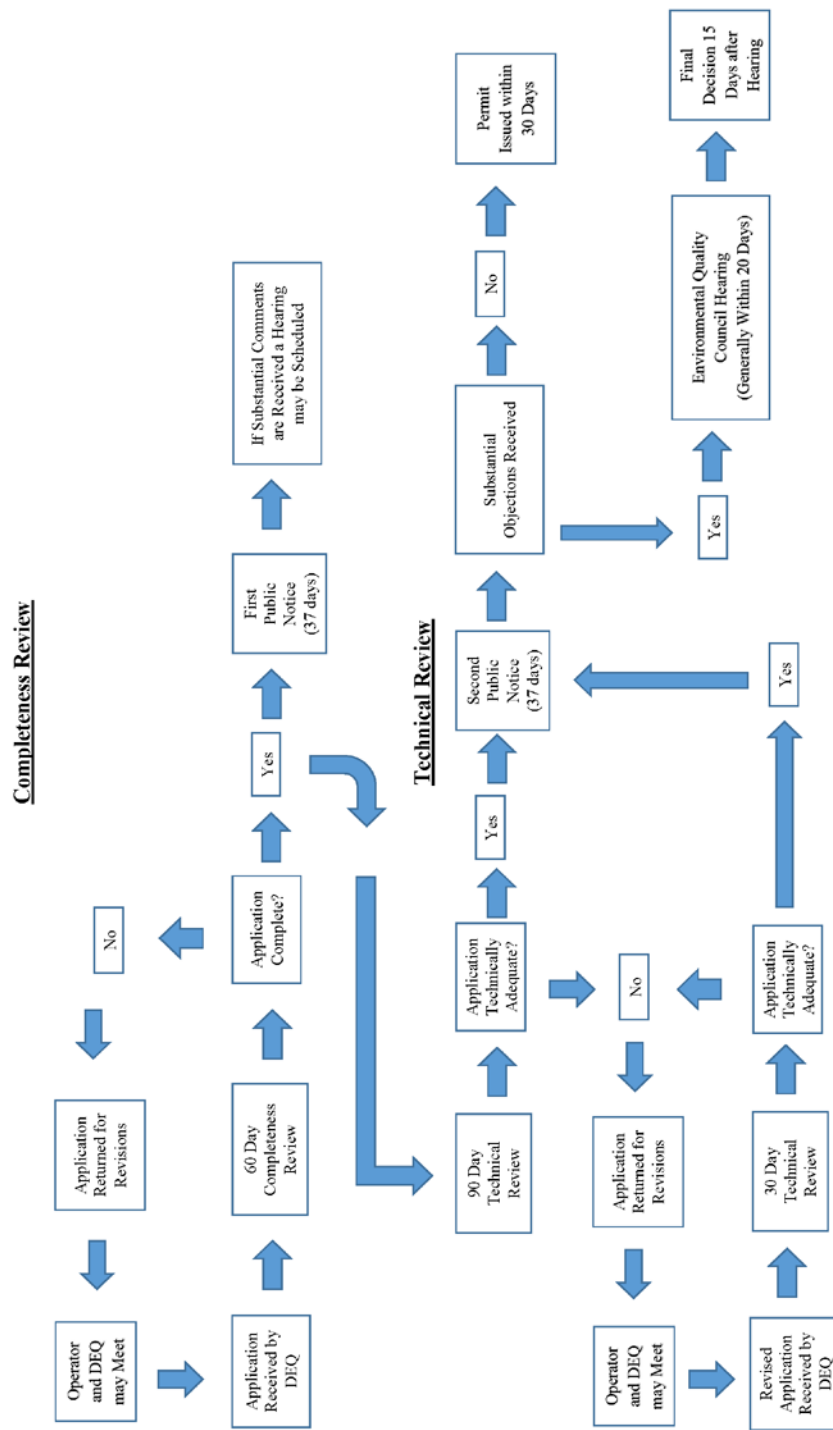
SECTION 4. PERMITTING

- commercial solid waste facility standards, if applicable
- supporting documentation (maps, cross-sections, etc.)

Why are applications submitted so far in advance?

- the process is lengthy
- the process is thorough (See Figures 4A-1 for Permit Processes and Part B for additional information on public comment periods)

Figure 4A-1 Solid Waste Permit Process
New Permits, Permit Renewals, Closure Permits (Except General Closure Permits for Municipal Solid Waste Landfills), and
Major Permit Amendments for Municipal Solid Waste Landfills with Lifetime Permits
 (The process below is based on W.S. § 35-11-502)



PART B. PUBLIC NOTICE AND COMMENT PERIOD

Developing a new landfill site or making significant changes in the operation of an existing facility can be a difficult task for many reasons. Not only are there the technical aspects to consider, but public acceptance of the proposed new site or facility change is crucial to the success of the endeavor. In particular, municipal landfills in Wyoming are usually funded by public monies and designed to serve that public. Negative public response can result from simply neglecting to include local constituents in the decision-making process. Involving the public to an extent above and beyond the minimum public notice and comment periods required by regulation is almost always a cost-effective decision.

Involve the Public Early in the Permitting Process to:

- address public concerns in the initial permit application
- minimize potential negative public response
- avoid permitting expenses for sites that won't achieve public acceptance

Regulations Require Public Notice and Comment Periods for:

- new solid waste management facility permits
- renewal permits
- closure permits
- major amendments to existing facility permits

Initial Public Notice Requirements:

- once you are notified by DEQ that your application is "complete", you have 15 days to provide the public notice
- text of the notice is supplied by DEQ
- send written notice of the permit application to individuals/organizations listed below
- arrange for publication of the written notice (once a week for two (2) consecutive weeks) in a newspaper of general circulation within the county in which the site is located
- You must submit an electronic copy of the written notice, with publication dates, to the DEQ prior to publication so the legal notice can be posted to the DEQ's website and emailed through the DEQ's Listserv
- provide DEQ with documentation, such as return receipt cards and publisher's

affidavits that written notice and publication have been accomplished

Send Written Notice of the Permit Application to:

- landowners with property within 1/2 mile of the site, by certified, return receipt requested mail
- each member of the interested parties mailing list maintained by DEQ, by first class mail
- mayor of each city or town within 50 miles of the site, by first class mail
- county commission for the county in which the site is located, by first class mail
- any solid waste district for the county in which the site is located, by first class mail

The Initial Public Comment Period for Complete Applications:

- begins on the first date of publication
- ends at 5:00 pm 30 days after the last date of publication
- may include a public hearing at the discretion of the DEQ

Second Public Notice Requirements:

- once DEQ has determined that an application is suitable for publication (the application is both complete and technically adequate) and you receive a "proposed permit" from the DEQ, you have 15 days to provide the public notice
- text of the notice is supplied by DEQ
- send written notice of the permit application to individuals/organizations listed below
- arrange for publication of the written notice (once a week for two (2) consecutive weeks) in a newspaper of general circulation within the county in which the site is located
- You must submit an electronic copy of the written notice, with publication dates, to the DEQ prior to publication so the legal notice can be posted to the DEQ's website and emailed through the DEQ's Listserv
- deliver a copy of the permit application, the DEQ's review and the draft permit to the local public library and county clerk for public viewing for the duration of the comment period
- provide DEQ with documentation, such as return receipt cards and publisher's affidavits that written notice, publication, and document deposition have been accomplished

Send Written Notice of the Proposed Permit to:

- each member of the interested parties mailing list maintained by DEQ, by first class mail
- landowners with property within 1/2 mile of the site, by certified, receipt requested mail
- mayor of each city or town within 50 miles of the site, by certified, receipt requested mail
- county commission for the county in which the site is located, by certified, receipt requested mail
- any solid waste district for the county in which the site is located, by certified, receipt requested mail

Second Public Comment Period:

- begins on the first day of publication of the notice in a newspaper of general circulation
- ends at 5:00 pm 30 days after the last date of publication
- may include a public hearing if substantial written objections are received

PART C. LOCATION STANDARDS

Location standards prohibit the construction or location of municipal landfills in certain areas in which landfill development would pose an unreasonable risk for adverse effects on human health or the environment. All of the location standards applicable to landfills are listed in Chapter 2 of the Wyoming Solid Waste Rules and Regulations.

Some location standards apply to existing facilities. If an existing facility violates an applicable location standard, the landfill owner is required to specifically demonstrate to the DEQ that the location standard has been properly addressed.

Location Standards:

- expressly prohibit new facilities and lateral expansions of existing facilities from waste disposal in certain areas
- prohibit location or construction of facilities in some areas (see standards that may be may be eligible for a variance authorization below)
- do not apply to facility access roads
- prohibit waste disposal at existing sites in certain areas subject to specific determinations placed in the operating record

New Facilities

New facilities shall not be located in violation of Wyoming Statute 35-11-502(c) or the standards in Chapter 2. Note that a facility is the total contiguous area described in the permit application and which is occupied by any solid waste management area, unit, site, process, or system and the operation thereof including, but not limited to, equipment, buildings, solid waste treatment, storage, transfer, processing, and disposal areas, buffer zones, monitor well systems, fire lanes, working area litter and access fences, systems for the remediation of releases to the environment, and perimeter access control fences. The term "facility" does not include contiguous or noncontiguous lands that may be owned or leased by the applicant, are not disturbed by solid waste management operations and are external to the contiguous area occupied by the solid waste management area, unit, site, process, or system.

W.S. § 35-11-502(c):

No person, except upon a variance granted by the Director upon recommendation of the Administrator after public hearing and upon written findings that the variance will not injure or threaten to injure the public health, safety or welfare, shall locate or construct a solid waste management disposal facility larger than one (1) acre within:

- One (1) mile of the boundaries of an incorporated city or town;
- One (1) mile of a public school except with the written consent of the school district board of trustees or one (1) mile of an occupied dwelling house except with the written consent of the owner;
- One half (1/2) mile of the center line of the right of way of a state or federal highway unless screened from view as approved by the DEQ; or
- One half (1/2) mile of a water well permitted or certificated for domestic or stock watering purposes except with written consent of the owner of the permit or certificate.

Chapter 2 Facility Location Standards:

- Local zoning ordinances: Facility locations shall not be in conflict with local zoning ordinances or land use plans that have been adopted by a county commission or municipality.
- Wild and Scenic Rivers Act: Facility locations shall not diminish the scenic, recreational and fish and wildlife values for any section of river designated for protection under the Wild and Scenic Rivers Act, 16 USC 1271 et seq., and implementing regulations.
- National Historic Preservation Act: Facilities shall not be located in areas where they may pose a threat to an irreplaceable historic or archeological site listed pursuant to the National Historic Preservation Act, 16 USC 470 et seq. and implementing regulations, or to a natural landmark designated by the National Park Service.
- Endangered Species Act: Facilities shall not be located within a critical habitat of an endangered or threatened species listed pursuant to the Endangered Species Act, 16 USC 1531 et seq., and implementing regulations, where the facility may cause destruction or adverse modification of the critical habitat, may jeopardize the continued existence of endangered or threatened species or contribute to the taking of such species.
- Big game winter range: Facilities shall not be located within critical winter ranges for big game unless after considering information from the Wyoming Game and Fish Department, the Administrator determines that facility development would not conflict with the conservation of Wyoming's wildlife resources.
- Sage Grouse: Note that restrictions regarding sage grouse may be applicable. Operators must contact the DEQ to find out if there are any applicable restrictions.

New Units, Existing Units and Lateral Expansions:

Note the difference between a unit and a facility. A unit is a discrete area of land or an excavation that receives municipal solid waste and that is not a land application unit, surface impoundment, injection well, or waste pile. The roads leading to MSWLFs are not be subject to the location standards described below.

New units, existing units and lateral expansions shall not be located in violation of the following standards:

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- Airport safety:
 - New MSWLF units, existing units, and lateral expansions located within 10,000 feet (3,048 meters) of any airport runway end used by turbojet aircraft or within 5,000 feet (1,524 meters) of any airport runway end used by only piston-type aircraft must be designed and operated so that the MSWLF unit does not pose a bird hazard to aircraft.
 - Owners or operators proposing to site new MSWLF units and lateral expansions within a five(5)-mile radius of any airport runway end used by turbojet or piston-type aircraft shall notify the affected airport and the Federal Aviation Administration (FAA) and include documentation of the notification in the permit application.
- Floodplains: New MSWLF units, existing units, and lateral expansions shall not be located in a 100-year floodplain unless the operator demonstrates that the unit will not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste.
- Wetlands: New MSWLF units and lateral expansions shall not be located in wetlands.
- Fault areas: New MSWLF units and lateral expansions shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time unless the owner or operator demonstrates that an alternative setback distance of less than 200 feet (60 meters) will prevent damage to the structural integrity of the MSWLF unit and will be protective of human health and the environment.
- Seismic impact zones: New MSWLF units and lateral expansions shall not be located in seismic impact zones, unless the owner demonstrates to the Administrator that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site;
- Unstable areas: New MSWLF units and lateral expansions shall not be located in an unstable area unless the owner has demonstrated to the Administrator that engineering measures have been incorporated into the facility's, unit's, or area fill's design to ensure that the integrity of the structural components of the facility, unit, or area fill will not be disrupted. The demonstration must consider:
 - On-site or local soil conditions that may result in significant differential settling;
 - On-site or local geologic or geomorphologic features; and

- On-site or local human-made features or events (both surface and subsurface).

PART D. VARIANCE PROCEDURES

A proposed facility or lateral expansion of an existing facility may not meet the location standards specifically cited in W.S. 35-11-502(c). If that is the case, there is an option to request a variance from the location standards in order to pursue permitting of the facility. A variance is essentially authorization, granted by the DEQ, to violate the location standard because of site specific circumstances. If the variance is not granted, DEQ cannot issue a permit to a facility that violates the specified location standards.

A Variance Application Is:

- a request to allow a new facility or lateral expansion to be sited in violation of one of the location standards in W.S. 35-11-532(c)
- submitted to DEQ for review
- reviewed by DEQ within 90 days of submittal
- forwarded to the DEQ Director with the DEQ's findings and recommendations
- granted or denied by the Director

The Director Will Only Grant a Variance If:

- granting the variance will not injure or threaten to injure the public health, safety or welfare
- alternative locations which meet the location standards are not available within a reasonable distance
- it is not possible to use other permitted disposal facilities within a reasonable distance
- special or unique circumstances apply to justify granting the variance

Variance applications need to provide sufficient information on the site-specific circumstances to allow the DEQ to evaluate whether a variance is warranted. Certain basic information about the facility is required for all variance applications while other information is only necessary if it applies to the particular location standard for which the variance is being requested.

In granting any variance the Director will condition the variance such that it applies only to the facility described in the application. Changes to the facility size,

type or source of waste, rate at which waste is received, or any other aspect of the facility may render the variance invalid as determined by the Director.

All Variance Applications Provide Information Concerning:

- the name, address, telephone number of the applicant
- legal description of the property
- proposed size of the facility
- amount, type and rate (tons per day) of waste disposal, waste sources, site capacity and site life
- USGS topo map showing the site boundaries
- names and addresses of property owners within 1 mile of the site boundary
- the lack of alternative waste disposal options (other permitted sites or alternative locations that would meet the location standards)
- any special circumstances that would justify granting the variance
- the basis for the contention that granting the variance would not injure or threaten to injure the public health, safety or welfare

A Variance Application for Proximity to a Water Well Includes:

- information on the site geology and hydrology with supporting data
- a detailed description of any containment system (cap and liner)
- a detailed description of surface water diversion structures
- a detailed description of the ground water monitoring program
- an analysis of contamination potential

A Variance Application for Proximity to Towns, Schools or Houses Includes:

- information on the design features of any methane control and monitoring systems used to prevent methane migration to buildings within 1 mile of the facility
- an analysis of potential additional traffic and any decrease in public safety as a result
- an analysis of operating practices with respect to production of odors, dust, litter, insects, noise, animal and human health, general aesthetics and the capacity to present a public nuisance at that location

A Variance Application for Proximity to, and Screening from, State and Federal Highways Includes:

- Information on how the facility design and operation minimizes visual impact to the highway

PART E. PERMIT AMENDMENTS

Once a landfill has been permitted, the design, construction, operation, closure and post-closure activities are required to be conducted in accordance with the approved plan. Landfill operations are dynamic and it is often necessary to make changes in the approved plan after the initial permitting documents are approved.

All amendments must comply with the location, design and construction, operating, monitoring, financial assurance and closure standards of the applicable chapters of these rules and regulations. No amendment may be implemented without the prior written authorization of the Administrator.

Operators must submit a written application describing the amendment(s) sought, including additional plates and/or drawings as necessary to completely describe the proposed amendment. The application needs to include replacement pages that can be inserted into the permit application to completely describe the changes proposed.

The DEQ will review the amendment application within sixty (60) days and provide a written response to the operator. If the DEQ determines that the amendment is minor and the proposed amendment application demonstrates compliance with all applicable standards, the operator will be authorized to implement the amendment immediately following written approval. If the DEQ determines that the amendment is major the permit amendment process must proceed following the same review and public notice requirements as a new permit. This process is described in Part B above and illustrated in Figure 4A-1.

What is a Major Amendment?

A major amendment (change) means a change to any solid waste management facility location, design or construction, or to any operating, monitoring, closure or post-closure activities, involving one or more of the following items:

- The total permitted volumetric capacity of the facility is to be increased by more than five percent (5%);

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- The effectiveness of any liner, leachate collection or detection system, gas detection or migration system, or pollution control or treatment system may be reduced; or
- The facility modification will, in the judgment of the Administrator, be likely to alter the fundamental nature of the facility's activities.

How Do You Know If a Proposed Change Is "Major"?

- consult with the DEQ for a determination of "major" or "minor"

SECTION 5
LANDFILL CONSTRUCTION MANAGEMENT

SECTION 5

LANDFILL CONSTRUCTION MANAGEMENT

TRAINING OBJECTIVES:

- 1) To provide landfill managers with a clear understanding of the regulatory standards that must be met with respect to slope stability, material balance, surface water control systems, engineered containment systems, methane control systems and petroleum contaminated soils treatments areas.
- 2) To explain the rationale and intent of the regulatory standards.
- 3) To familiarize landfill managers with methods and suggestions that will assist them to comply with the regulatory standards.

PART A. SLOPE STABILITY

To ensure the safety of the public and landfill employees at landfill facilities located in unstable areas, fault areas and/or seismic impact zones, owners/operators must assess the ability of the site embankments and slopes to maintain a stable condition. Landfills that are **not** located in unstable areas, fault areas and/or seismic impact zones must also assess the stability of slopes if the constructed slopes (e.g. trench walls) at the facility are steeper than 1.5 horizontal : 1 vertical (1.5H:1V).

Refer to Section 2, Part D of this workbook for a description of unstable areas, fault areas and seismic impact zones.

As part of their demonstration to site a landfill in an unstable area, fault area or seismic impact zone, a stability assessment of the site should be conducted. Whether or not an embankment or slope is stable depends upon the geometry of the slope and the soil/rock type. The stability assessment requires:

Evaluation of Subsurface Conditions:

The evaluation of subsurface conditions includes:

- assessing the stability of foundation soils, adjacent embankments and slopes

- investigating the geotechnical and geological characteristics of the site to establish soil strengths and other engineering properties by performing standard penetration tests, field vane shear tests and laboratory tests
- testing the soil properties such as water content, shear strength, plasticity and grain size distribution

Analysis of Slope Stability:

Slope stability analysis includes:

- analyzing both excavated side slopes and above ground embankments
- analyzing the structural integrity of a cut slope or dike
- evaluating a design configuration for its stability under all potential hydraulic and loading conditions, including conditions that may exist during construction of an expansion (e.g. excavation)

Examination of Related Design Needs:

This examination includes an evaluation of the following design options:

- changing slope geometry through reduction of the slope height, flattening the slope angle or excavating a bench in the upper part of the slope
- placing compacted earth or rock fill at and beyond the slope's toe to buttress the slope
- placing retaining structures
- using geotextiles and geogrids
- installing drains at the toe of the slope to relieve excess pressures
- pumping to lower groundwater levels
- controlling surface water drainage to decrease infiltration

There are numerous methods available for performing slope stability analyses. The method selected should be based on the soil properties and the anticipated mode of failure. A popular method is use of the computer program PC STABL, a two-dimensional (2D) model that computes the minimum critical factors of safety between layer interfaces. Whichever method is selected for analyzing slope stability, rationale for choosing that particular method should be provided.

Monitoring of slope stability during construction activities may be appropriate because of the additional stresses placed on slopes, foundations and dikes as a result of excavation and filling activities.

Pore water pressure can be monitored with piezometers screened in the sensitive area. Lateral movements of structures may be detected by surveying the horizontal and vertical movements and settlement may be monitored by surveying ground surface elevations and comparing them with established benchmarks or other areas not likely to experience changes in elevation.

For sites where slope stability analyses have not been performed, excavated slopes shall not exceed a ratio of 1.5H:1V, unless the owner/operator can demonstrate that steeper slopes will be in compliance with the open excavation requirements of Wyoming Occupational Health and Safety Rules and Regulations.

PART B. MATERIAL BALANCE

To ensure that an adequate supply of daily, intermediate and final cover is available to properly operate the facility through the closure period, a material balance should be calculated for all landfill facilities.

Cover material volume requirements depend on the surface area of wastes to be covered and the thickness of the soil needed to perform particular functions. Cell configuration can greatly affect the volume of cover material needed.

As shown in the Example 1, the surface area to be covered should be kept as small as practical to help conserve cover material.

An estimate of the volume of daily cover material required can be calculated by multiplying the average surface area covered each day by the depth of cover material required (minimum of 6 inches). The same procedure can be used to calculate the estimated volume of intermediate cover and final cover. If the average surface area covered each day is not known, an estimate of the daily cover required based on published waste to cover material ratios can be used.

Example 1

Given a waste volume of 25 tons per day and an assumed in-place density of 1,000 lbs/yd³, calculate the amount of daily cover (6" depth) required if:

- (a) the waste is spread and compacted to a depth of 1 feet before covering;
- (b) the waste is spread and compacted to a depth of 2 feet before covering.

Solution:

$$\text{In-Place Volume of Waste} = 25 \text{ tons} \times \frac{\text{yd}^3}{1,000 \text{ lbs}} \times \frac{2,000 \text{ lbs}}{\text{ton}} \times \frac{27 \text{ ft}^3}{\text{yd}^3} = 1,350 \text{ ft}^3$$

- (a) 1 foot deep:

$$\text{Surface area of waste to be covered} = 1,350 \text{ ft}^3 \div 1 \text{ ft} = 1,350 \text{ ft}^2$$

$$\text{Daily cover material volume} = 1,350 \text{ ft}^2 \times 0.5 \text{ ft} = 675 \text{ ft}^3 \div 27 = \underline{25 \text{ yd}^3}$$

- (b) 2 foot deep:

$$\text{Surface area of waste to be covered} = 1,350 \text{ ft}^3 \div 2 \text{ ft} = 675 \text{ ft}^2$$

$$\text{Daily cover material volume} = 675 \text{ ft}^2 \times 0.5 \text{ ft} = 337.5 \text{ ft}^3 \div 27 = \underline{12\frac{1}{2} \text{ yd}^3}$$

Table 5B-1 shows an example of a daily cover material balance for a trench type operation using an estimated waste to cover material ratio of 3:1.

Table 5B-1
Daily Cover Material Balance

TRENCH	TOTAL VOLUME ¹ (yd ³)	SOLID WASTE VOLUME ² (yd ³)	COVER MATERIAL VOLUME ³ (yd ³)	COVER MATERIAL SURPLUS ⁴ (yd ³)
1	42,000	31,500	10,500	25,200
2	47,000	35,250	11,750	28,200

SECTION 5. LANDFILL CONSTRUCTION MANAGEMENT

TRENCH	TOTAL VOLUME ¹ (yd ³)	SOLID WASTE VOLUME ² (yd ³)	COVER MATERIAL VOLUME ³ (yd ³)	COVER MATERIAL SURPLUS ⁴ (yd ³)
3	46,000	34,500	11,500	27,600
4	32,000	24,000	8,000	19,200
5	20,000	15,000	5,000	12,000
6	5,000	3,750	1,250	3,000
TOTALS	192,000	144,000	48,000	115,200

NOTES:

1. Total volume of soil in trench
2. Published ratio by volume of solid waste to cover material for landfills approaches 3:1. Thus,
SOLID WASTE VOLUME = TOTAL VOLUME $\times \frac{3}{4}$
3. TOTAL VOLUME - SOLID WASTE VOLUME
4. (TOTAL VOLUME \times 0.85) - COVER MATERIAL VOLUME

The shrink factor of 0.85 shown in footnote 4 of Table 5B-1 is used to compensate for the loss of soil volume due to handling (stockpiling and excavating) and due to compacting the soil to a greater density than it was “in-place”.

The waste to cover ratio (3:1) used in Table 5B-1 means for every 3 parts of solid waste, there is 1 part of cover material. The waste to cover ratio is affected by:

- the amount of surface area of waste being covered, and
- how much the waste is compacted prior to covering

Landfill operations that do a better job at keeping the surface area small and the compaction high, have a higher waste to cover ratio.

The amount of cover material required to cover a closed landfill with two (2) feet of final cover and six (6) inches of topsoil can be calculated as shown in Example 2.

Example 2:

Calculate the amount of cover material and topsoil required for a 10 acre site:

$$\text{Size of disturbed area} = 10 \text{ acres} \times \frac{43,560 \text{ ft}^2}{\text{acre}} = 435,600 \text{ ft}^2$$

$$\text{Volume of cover material} = 435,600 \text{ ft}^2 \times 2 \text{ ft} = 871,200 \text{ ft}^3 \div 27 = \underline{32,300 \text{ yd}^3}$$

$$\text{Volume of topsoil} = 435,600 \text{ ft}^2 \times 0.5 \text{ ft} = 217,800 \text{ ft}^3 \div 27 = \underline{8,067 \text{ yd}^3}$$

If the material balance shows an excess of cover material will be available from on-site excavations, the facility's closure plan should show the use of the excess material.

For example, the excess material could be:

- used to raise the final topography
- stockpiled for potential use during post-closure (e.g. repair settlement or erosion)
- hauled off site

If the material balance calculations show there is not a sufficient amount of cover material on site for daily cover and final cover requirements, the owner/operator must demonstrate that the required amount of cover material to operate the facility through the closure period will be available. For example, the demonstration may include importing cover material from off-site areas or using an alternate daily cover to decrease the amount of daily cover material required.

PART C. SURFACE WATER CONTROL STRUCTURES

Surface water must be controlled to minimize the amount of water entering the landfill and the active waste disposal areas and to protect the final cover on filled areas.

Surface water structures must be designed and constructed to:

- prevent flow onto the active portion of the landfill during the peak discharge from a 25-year storm

SECTION 5. LANDFILL CONSTRUCTION MANAGEMENT

- collect and control run-off from the active portion of the landfill from at least the water volume resulting from a 24-hour, 25 year storm
- sediment control structures shall be designed and constructed in accordance with Chapter 11 of the Water Quality Division Rules and Regulations

A 25-year storm event is defined as a storm of a particular magnitude having a 4% chance of occurring in any given year. Information on the 24-hour, 25-year storms can be obtained from "Precipitation-Frequency Atlas of the Western United States", Volume II-Wyoming. Alternatively, local meteorological data can be analyzed to estimate the precipitation volumes for the selected storm.

To estimate run-on, the local watershed must be identified and evaluated to document the basis for run-on design flows. Two methods that are widely used for estimating storm flows for designing run-on and/or run-off control systems are:

Soil Conservation Service Method: (Natural Resources Conservation Service)

This method estimates run-off volume from accumulated rainfall and then applies the run-off volume to a simplified triangular unit hydrograph for peak discharge estimation and total run-off hydrograph.

Rational Method:

This method approximates the majority of surface water discharge supplied by the watershed upstream from the facility. It is used for areas less than 200 acres.

After the estimated storm flows are obtained, the design and construction of adequate run-on and run-off structures can be implemented.

Refer to Section 2, Part F of this workbook for examples of run-on/run-off structures.

Run-on structures are required to collect and redirect surface waters to minimize the amount of surface water entering the landfill unit. **If storm water enters a landfill and contacts waste, the storm water becomes leachate and must be managed as leachate.**

Run-off from the active portion of the facility can be directed to a lined pond and either allowed to evaporate or pumped out and taken to a treatment plant. The pond must be sized to accommodate the volume generated from the particular storm and

must include a safety factor, or “free board” to prevent the run-off volume from overtopping the pond.

Run-off structures are designed to collect and control run-off from the active portion of the landfill which may have contacted waste materials. After a landfill or portion of a landfill has been closed with a final cover, storm water run-off from the closed section can be managed as storm water and not leachate.

Facilities shall be operated such that leachate, contaminated groundwater and/or surface water run-off from the active portion of the facility is not allowed to enter any waters of the United States, either on-site or off-site, unless authorized by a National Pollutant Discharge Elimination System (NPDES) permit issued pursuant to the Clean Water Act.

A NPDES permit is obtained under the WDEQ/Water Quality Division General Storm Water Permit for Construction Activities.

PART D. ENGINEERED CONTAINMENT SYSTEMS

New municipal solid waste landfill units and lateral expansions approved by the DEQ under W.S. § 35-11-502 and W.S. § 35-11-526 shall be constructed:

- In accordance with a performance based design approved by the DEQ in a performance based evaluation pursuant to W.S. § 35-11-526. Any performance based design approved must ensure that the concentration values for pollutants listed in the National Primary Drinking Water Regulations, 40 C.F.R. Part 141, will not be exceeded in the uppermost aquifer at the relevant point of compliance as determined under subsection (c) of this section; or
- With an engineered containment system that utilizes a composite liner and a leachate collection system that is designed and constructed to maintain less than a thirty (30) centimeter depth of leachate over the liner.

A composite liner means a system consisting of two (2) components:

- the upper component must consist of a minimum thirty (30) mil flexible membrane liner (FML) or a high density polyethylene (HDPE) that is at least sixty (60) mil thick; and
- the lower component shall consist of at least a two (2) foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second.

The flexible membrane liner component shall be installed in direct and uniform contact with the compacted soil component.

Figure 5D-1 shows a cross section and plan of a single lined landfill. This example does not illustrate the underlying clay layer of a composite liner. Clay liners are not easily damaged during construction and operation and if properly constructed, leakage will not be high. Synthetic liners allow less leakage but are difficult to protect from damage. Leakage through a synthetic liner could be higher than anticipated if damage during installation and landfill operation goes undetected. Thus, extreme caution is required during both the construction and operation of a landfill designed with a synthetic liner. The leachate collection layer over the FML provides some protection, but in nearly all cases a protective soil layer needs to be constructed over the leachate collection system to protect all liner components from damage. Extreme care must be taken during disposal of the first several feet of waste so that the liner is not damaged.

It has been said that “all liners leak”, but this statement is misleading. While composite liners are not 100% leak-proof, studies show (EPA 2002) that composite liners can be constructed to achieve hydraulic efficiency rates of 99% or more. Composite liners with good quality assurance/quality control (QA/QC) will substantially prevent leachate migration over the entire period of significant leachate generation for typical modern landfills.

SECTION 5. LANDFILL CONSTRUCTION MANAGEMENT

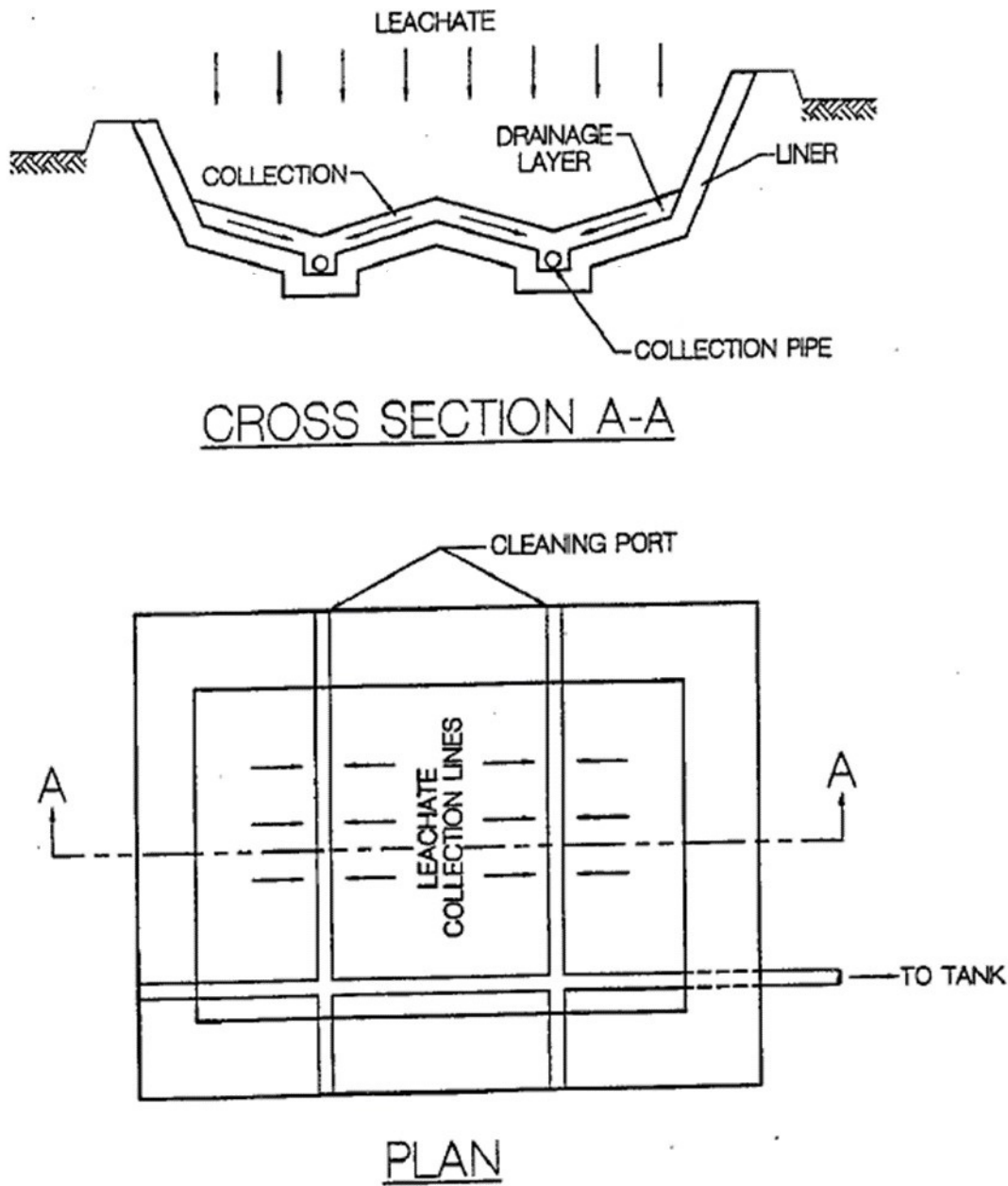


Figure 5D-1
Single Lined Containment Landfill
(Adapted from Bagchi, 1990)

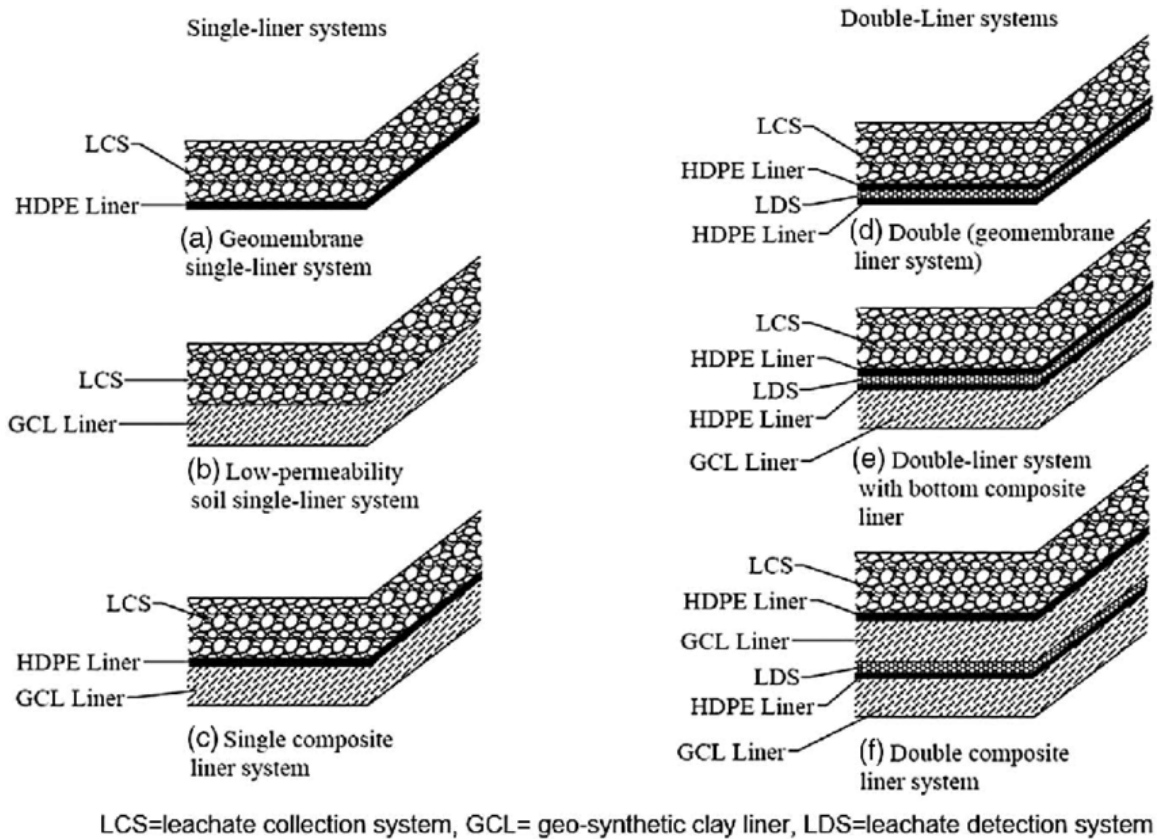


Figure 5D-2
Examples of Liner Systems

Design/Construction of Engineered Containment System Caps and Liners:

Compacted soil barrier layers shall be constructed in lifts which do not exceed six (6) inches in thickness, and uniform compaction of these lifts shall be assured through the use of appropriate equipment.

All engineered containment system components shall be supported by material of sufficient bearing strength to prevent subsidence and failure of any component. This bearing strength shall be documented through materials testing as approved by the DEQ.

Synthetic membranes used as part of any containment system shall be of a material and thickness which is suitable for the intended use, but in no case shall be less than 0.030 inches thick (30 mils) or 60 mils thick if the membrane consists of high

density polyethylene (HDPE). All synthetic membranes shall be underlain by a suitable bedding material and when used with a compacted soil component, in direct and uniform contact with the compacted soil component.

Lateral drainage layers included in composite cap and liner system designs shall be composed of either granular material or a synthetic drain net of suitable lateral permeability to promote acceptable drainage, as approved by the DEQ. Lateral drainage layers shall be protected from soil clogging by either a synthetic filter fabric or a graded granular layer of a design approved by the DEQ.

If required by the DEQ, leak detection systems shall be designed to efficiently identify failure of the overlying barrier layer

Quality assurance/quality control (QA/QC):

QA/QC plans must ensure adequate construction and testing of the containment system components, including applicable observations, inspections, tests, and measurements. Applicable standards from the American Society for Testing and Materials (ASTM) and Geosynthetic Research Institute (GRI) must be used. As applicable, the QA/QC Plans must address:

- foundations
- compacted soil layers
- flexible membrane liners
- leachate collection and removal systems including the operations/protective layer
- gas management systems
- final cover systems
- other components as required by the DEQ

For compacted soil layers QA/QC plans must describe how moisture content will be maintained or adjusted, the technique by which lift thickness will be maintained, the manner in which lifts will be compacted, the method used to measure moisture content and density in the field during construction, and the frequency of moisture content and density testing.

For synthetic membranes QA/QC plans must describe the method used to test 100% of all seams for leaks, the frequency of destructive testing for seam strength, the procedure to be followed for post-installation defect identification and repair, the results of testing or literature review which demonstrates the compatibility of the membrane material with the waste and/or waste leachate, and the procedures used to ensure each roll of membrane material meets the manufacturer's specifications for material

properties.

For lateral drainage layers QA/QC plans must describe the method used to ensure achievement of the approved grain size uniformity and layer thickness for granular layers, the method by which drainage layers shall be installed without damaging any imbedded leachate collection system, leak detection system or membrane, and the installation procedure for the filter fabric or granular filter layer overlying the drainage layer.

QA/QC plans must identify key personnel, their qualifications, and their role in the development and implementation of the QA/QC Plan.

After construction is complete the owner or operator must submit a certification, signed by an engineer licensed to practice in Wyoming, that the approved QA/QC plan has been carried out and that the unit meets the requirements of this section. Documentation supporting the engineer's certification shall be submitted with the certification. Wastes may not be accepted in the newly constructed unit without written authorization from the DEQ. Copies of the engineer's certification and supporting documentation must be maintained in the operating record.

See Figure 5D-3 and 5D-4 for an examples of engineered containment systems, including caps and liners. See Figure 5D-5 for an example of FML installation.

SECTION 5. LANDFILL CONSTRUCTION MANAGEMENT

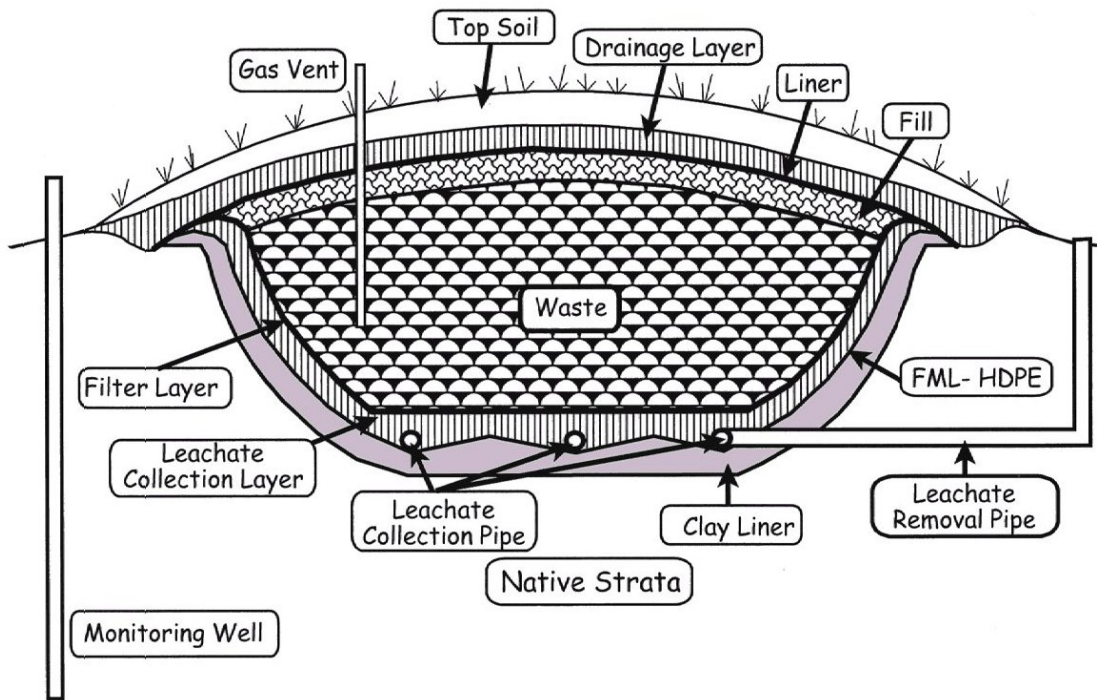


Figure 5D-3
Engineered Containment System

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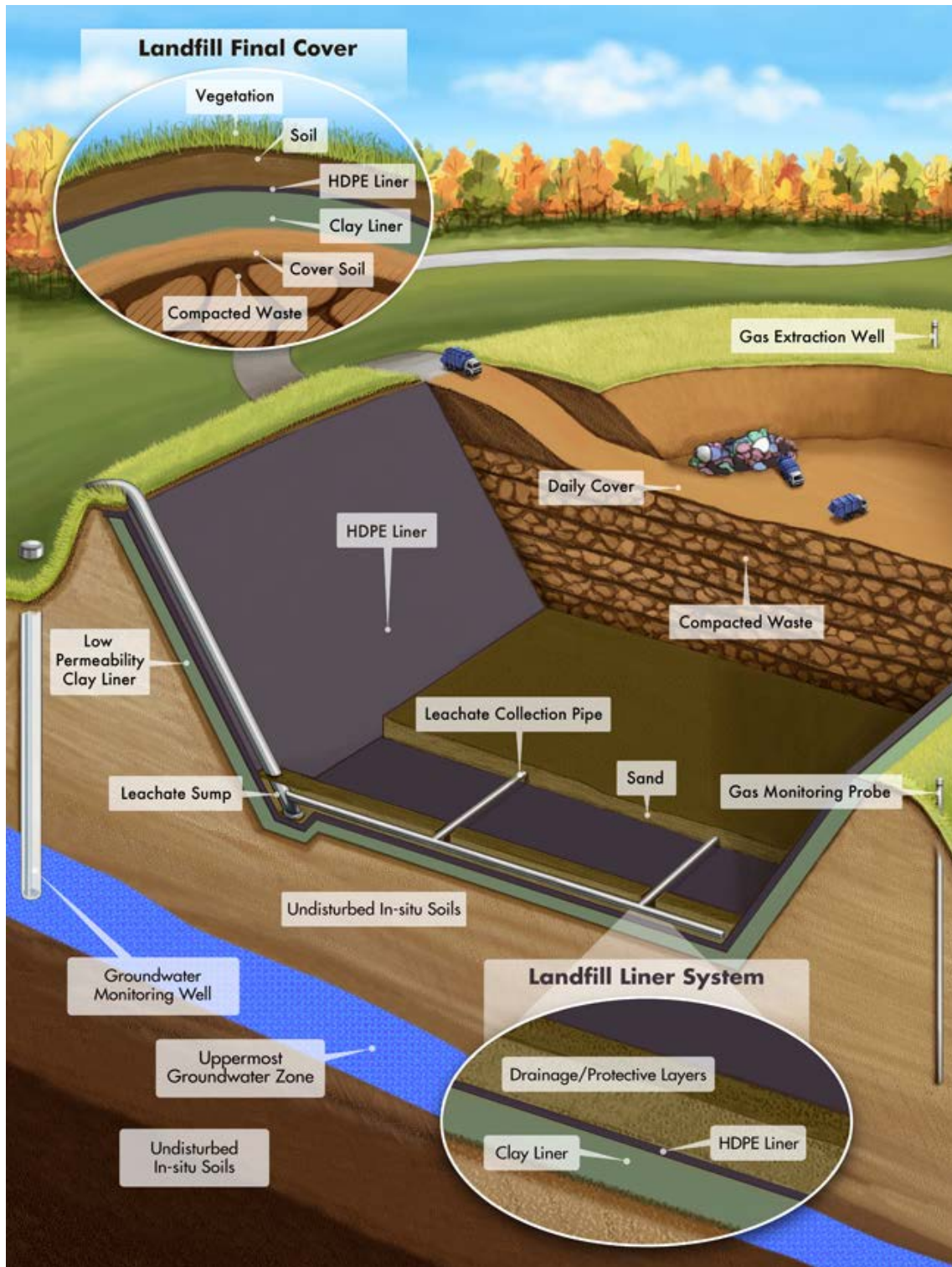


Figure 5D-4 Engineered Containment System at an Operating Landfill



Figure 5D-5
Flexible Membrane Liner (FML) Installation

PART E. METHANE CONTROL SYSTEMS

Methane gas produced by decomposing landfill wastes can migrate across the facility boundary and present a potential explosion hazard at off-site locations (see Section 6A - Solid Waste Decomposition). Similarly, methane can migrate into buildings located on the facility property. This can not only create an explosion hazard, but can cause exposures of workers to atmospheres lacking sufficient oxygen due to displacement by landfill gas. All structures on the facility must be designed to prevent the accumulation of methane such that the concentration of methane gas in facility structures does not exceed twenty-five percent (25%) of the lower explosive limit (LEL) for methane.

If required, the permit application shall include landfill gas management system design and construction information.

In order to minimize threats from methane, methane monitoring must be performed at the landfill perimeter to ensure that methane concentrations do not exceed the lower explosive limit (LEL) at the facility boundary or 25% of the LEL within on-site buildings. Refer to Section 6C - Methane Monitoring Program, for a more detailed explanation of the regulatory limits for methane levels.

In order to prevent high methane concentrations from entering on-site buildings or reaching the landfill perimeter, control systems can be installed between these areas and the source of methane generation (the refuse fill). Control systems can be installed to collect methane for its energy value, or to flare or vent methane to the atmosphere at an on-site location. Since migrating gas will follow the path of least resistance, methane control is primarily achieved by artificially providing a "preferred" gas migration pathway to the venting or recovery system.

Control system pathways include gas collection trenches or corridors constructed of more permeable materials than the surrounding fill. Layers usually consist of gravel or crushed rock with less than 10% (by weight) of the aggregate having grain sizes less than ½ inch diameter. This coarse material provides sufficient void space between the grains to transmit gases freely above the groundwater table. Methane control systems are operated as either active or passive systems. A hybrid system design can also be utilized to allow sequential passive and active operation.

Passive Gas Systems:

- vent to the atmosphere or flare unit
- rely on natural pressure gradients

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- utilize gas collection trenches/layers and/or barrier systems (see Figure 5E-1)
- are dependent on site geologic conditions
- have low operation and maintenance costs

Active Systems:

- vent to the atmosphere, flare unit or collection system
- utilize an artificially induced pressure gradient (see Figure 5E-2)
- may be preferable at deep landfills where excavation costs are high
- may be needed when passive systems do not provide adequate control
- have higher operation and maintenance costs
- consist of three (3) main types
 - Gas extraction well system - Removes gases from the landfill. A series of extraction wells extend to the lowest elevation of the refuse and are connected by a header pipe system to a vacuum pump/blower.
 - Air Injection Well System - Pushes gases away from the building or perimeter. Typically installed in natural ground to provide a barrier system between the building/perimeter and filled areas. Consists of a series of air injection wells connected to a header pipe system and blower.
 - Cut-off Trenches - System maintained under pressure to either remove gases or blow gases away from the building/perimeter. Gravel-filled trenches between the building/perimeter and filled areas extend the full depth of the landfill. Trenches are connected by a series of pipes to a blower or vacuum pump.

Hybrid (Flexible) Systems:

- consist of a vent/barrier trench with a horizontal perforated pipe incorporating one or more vertical risers (see Figure 5E-3)
- can be operated as a passive system
- can be operated as an active system by connecting risers to a blower/vacuum pump unit

Design Controls for On-Site Buildings

All on-site structures shall be designed to prevent accumulation of methane within the facility structures. How can methane accumulation in landfill buildings be prevented? For new building construction, a preferred alternative is a subsurface

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methane control system designed specifically for the particular building. These systems work on the same general principles as the passive control systems described above. For existing facilities, an adequate building ventilation system may be appropriate.

Quarterly monitoring of the atmosphere inside the building shall be performed to confirm that the control system is working effectively. Methane concentrations are expected to be less than 25% of the Lower Explosive Limit (LEL) within any building equipped with a properly operating methane control system (ventilation or subsurface).

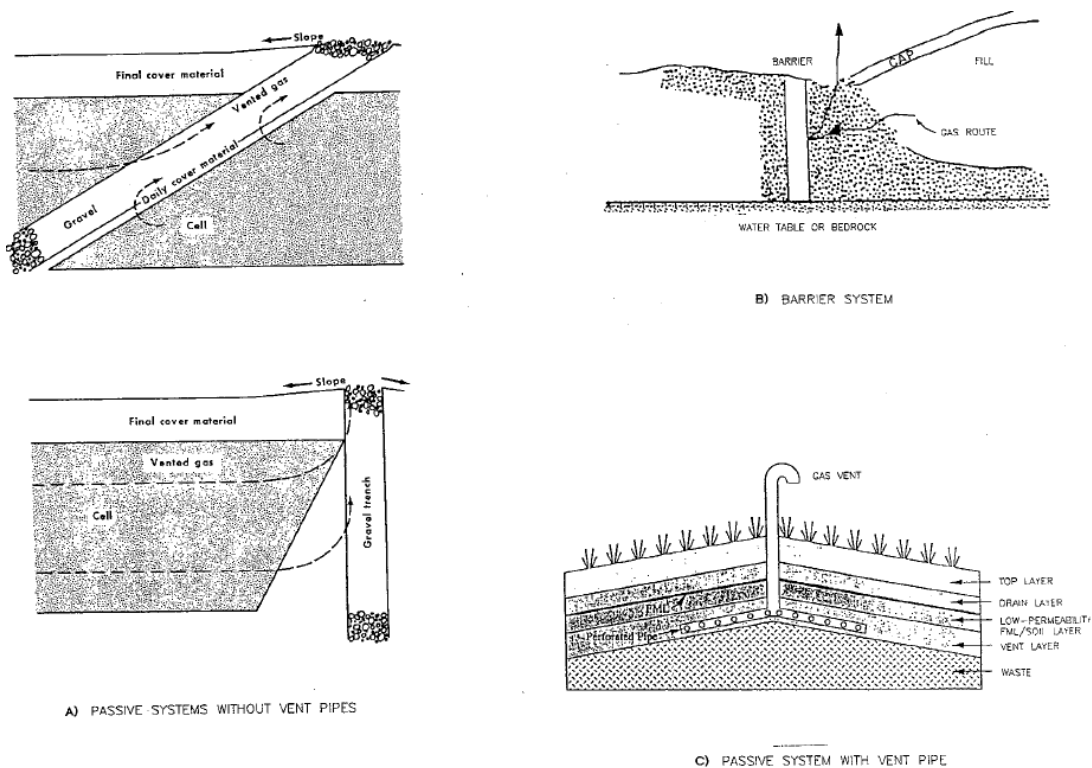


Figure 5E-1: Examples of passive methane control systems

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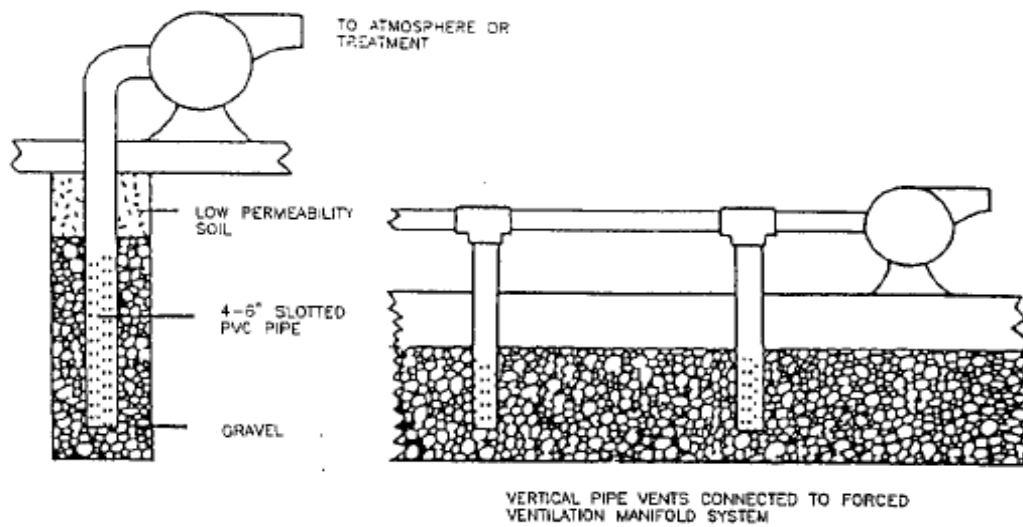


FIGURE 5E-2 :EXAMPLE OF ACTIVE METHANE CONTROL SYSTEM

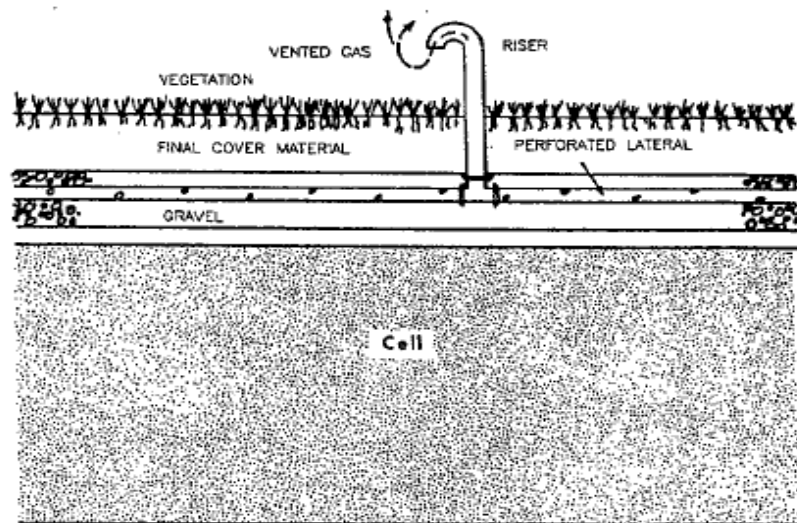


FIGURE 5E-3 :HYBRID METHANE CONTROL SYSTEM: PASSIVE VENT SYSTEM/
ACTIVE SYSTEM WHEN USED WITH FORCED VENTILATION

Methane Control Systems for Buildings:

Membrane sheeting or other approved methane barrier is usually placed beneath the structure's slab and foundation to encapsulate the underground portion of the building. This is installed in conjunction with a gravel-filled ventilation trench system to collect and remove landfill gases.

Figure 5E-4 shows a passive methane control system designed to allow sub-slab methane monitoring. Sections of perforated pipe are installed below the membrane to provide a preferred gas migration pathway, preventing methane from entering the building from the subsurface and venting it to the atmosphere instead. These vent pipes are equipped with sample taps to allow monitoring of methane accumulations. Probe assemblies, which are simply small sections of perforated pipe for gas sample collection, are also installed in a sand layer above the membrane liner. These are connected to a sample tap where monitoring equipment can be used to verify that methane gas has not crossed the membrane barrier. The effectiveness of the control system can therefore be evaluated by monitoring methane accumulations between the membrane and the building as well as between the membrane and the landfill.

SECTION 5. LANDFILL CONSTRUCTION MANAGEMENT

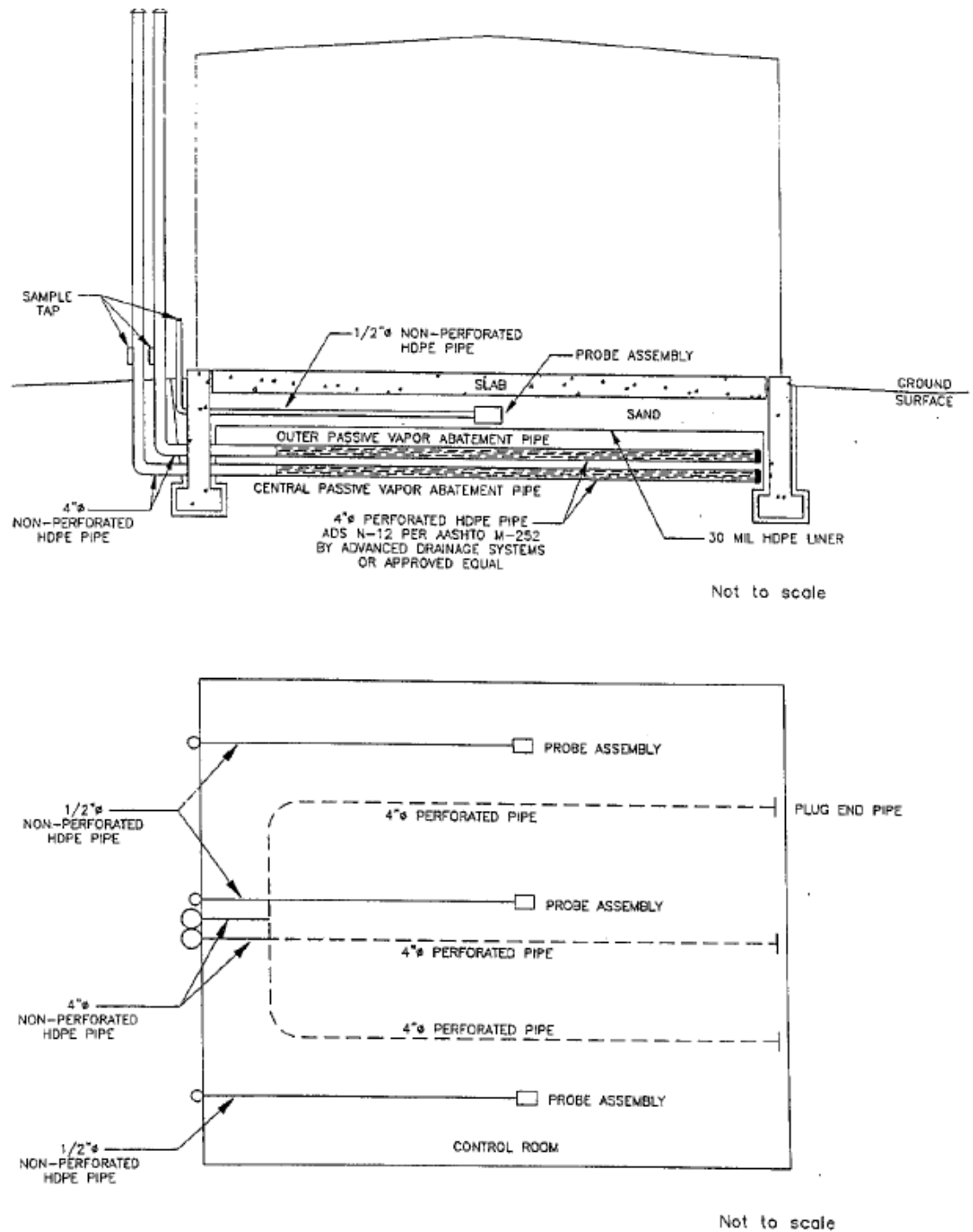


FIGURE 5E-4 :SCHEMATIC PLAN AND CROSS SECTION OF PASSIVE METHANE CONTROL SYSTEM FOR ON-SITE BUILDING

SECTION 6

LANDFILL MONITORING AND REPORTING

SECTION 6

LANDFILL MONITORING AND REPORTING

TRAINING OBJECTIVES:

- 1) To provide landfill operators and managers with an understanding of the solid waste decomposition process and how it contributes to long-term landfill settlement and the formation of gases and leachate that are the basis for landfill monitoring.
- 2) To identify specific methods that can be employed by landfill operators to control waste decomposition, minimize settlement problems and reduce pollution potential.
- 3) To explain proper data acquisition, data management, and data reporting to comply with required environmental monitoring program(s).
- 4) To provide landfill operators and managers with tips and information that can be used to simplify environmental monitoring programs while maintaining acceptable quality assurance and quality control.
- 5) To identify information and reference materials that can be used by landfill operators and managers to ensure that landfill environmental monitoring programs are implemented efficiently and that acquired data are accurate.

PART A. SOLID WASTE DECOMPOSITION

The majority of solid wastes buried in a landfill will undergo decomposition processes that can be physical, chemical and biological in nature. Waste materials can dissolve, they can chemically react with other landfill components, and they can be used as nutrients by microorganisms naturally present in the landfill environment. Examples of these processes are given below:

<u>Type of Decomposition Process</u>	<u>Example of Decomposition Process</u>
Physical	Dissolution
Chemical	Metal Oxidation/Reduction
Biological	Microbial Decay

Organic wastes such as food products degrade rapidly while others, such as plastic and glass, are relatively resistant to degradation. Studies show that the

majority of waste decomposition occurs in the first five (5) years after waste burial. The amount of overall degradation that occurs in a landfill and the speed with which it occurs, depends on the types of wastes and a variety of other factors:

Decomposition Factor	Conditions that Promote Decomposition
Waste Type	Organic Wastes (e.g. food) decompose more readily than Inorganic Wastes (e.g. metals)
Physical Characteristics of Waste	High Surface Areas promote decomposition (sawdust would degrade more rapidly than a piece of wood)
Moisture Content of Waste	Wet Wastes promote decomposition (Wet food degrades more rapidly than dry food)
Oxygen Content of Waste	High Oxygen Contents promote decomposition (see Section 1 of this part for more detail)
Waste Compaction	Low Compaction promotes decomposition (more moisture and air can seep in)
pH of waste	pH between 6 and 8 Standard Units is optimal for decomposition
Temperature of the Waste	Temperatures between 10 ^o and 45 ^o C are optimal for decomposition
Toxicity of the Waste	Low Toxicities are more favorable for decomposition

Gas Generation:

As wastes are broken down by subsurface microbes, a large portion of the organic components are converted to gaseous end-products known as "biogenic" gases. The two (2) main components of these gases are:

- carbon dioxide (CO₂)
- methane (CH₄)

When wastes are first buried in a landfill, the majority of the initial decay is carried out by bacteria that use oxygen (aerobic decay). These bacteria produce

large quantities of carbon dioxide as a by-product. Carbon dioxide is an indicator of biological activity but does not present a particular safety hazard at a facility.

Carbon Dioxide Is:

- odorless and colorless
- highly soluble in water (forms weak carbonic acid)
- heavier than air
- non-combustible

As the amount of free oxygen in the buried fill is used up, microbes that do not utilize oxygen take over the decay processes (anaerobic decay). Anaerobic decay is a much slower process. Carbon dioxide is still a by-product, but in addition methane and hydrogen sulfide gases may be produced. Landfill gas produced in a mature landfill may contain as much as 40 to 60% methane. Both methane and hydrogen sulfide can produce hazards at the facility.

Methane Is:

- odorless and colorless
- formed in the absence of oxygen
- lighter than air
- not very soluble in water
- **explosive** (5 to 15% in air)

Hydrogen sulfide is typically produced in small quantities because it is formed only when sulfate is available, as would be the case with buried gypsum board (calcium sulfate) or similar material. In addition, if there are dissolved metals, sulfides would tend to precipitate with the metals and not appear as hydrogen sulfide gas. However, hydrogen sulfide is important because it is an indicator of biodegradation and is toxic in very small quantities.

Hydrogen Sulfide is:

- formed in the absence of oxygen
- formed from conversion of sulfate compounds
- **toxic** (IDLH = 300 ppm)
- heavier than air
- has the odor of rotten eggs

The composition of landfill gas changes with the amount of time that wastes have been buried in the landfill. In general, the composition of landfill gas will tend to stabilize with increasing burial time. The exact composition of the landfill gas at any one time depends on the waste composition and subsurface conditions. The composition of a typical landfill gas is listed in the following table:

Typical Landfill Gas Composition:

Type of Gas	Concentration (% by Volume)
Methane	40 to 60
Carbon Dioxide	40 to 60
Nitrogen	<5%
Oxygen	<1%
Hydrogen	<1%
Hydrogen Sulfide	<1%
Other Gasses	<1%

Movement of Landfill Gas:

Methane is the most significant component of landfill gas because it is lighter than air and because it will tend to rise and migrate from a landfill. Since methane is not soluble in water, the groundwater table is considered a barrier to gas migration. Above the groundwater table, methane can move vertically through cracks and porous soils to the top of the landfill where it can be released to the ambient air. If vertical migration is restricted, methane can move laterally through porous soils along the least restrictive pathway until vented to the atmosphere.

Methane Gas Will:

- rise
- not travel through water
- diffuse from high concentration areas to low concentration areas
- move in response to pressure gradients
- travel along the path of least resistance

Methane May Travel:

- along pipes, conduits, drain tiles, sewers
- into basements, crawl spaces, cracks in floors
- into collection or extraction systems
- along barriers

Migration and movement of landfill gas is a serious concern due to potential **EXPLOSIONS!** In the subsurface, oxygen is not present at significant levels when methane is produced. Since oxygen is necessary for combustion, methane does not present an explosion hazard within the fill. However, once concentrations of methane come into contact with air, as in a landfill building or adjacent home, the danger of explosion can be imminent and difficult to detect. Structures have exploded and people have lost their lives due to migrating methane.

Signs of Methane Movement Can Be Detected By:

- yellow vegetation
- wilted vegetation
- stunted plant growth
- areas of patchy growth (bare spots)

Leachate Generation:

Leachate is the liquid that results from the percolation of fluids through solid waste. Leachate contains materials dissolved from the waste as well as a variety of waste decomposition products. The quantity of leachate produced depends on the volume of incoming moisture, as illustrated by the simplified landfill water budget depicted in Figure 6A-1.

The Initial Moisture That Creates Leachate Is Derived From:

- direct precipitation
- snowmelt and surface water run-on
- liquid wastes
- liquid components of wastes
- ground water contact

The contaminants in the leachate will be influenced primarily by the waste characteristics. The overall composition of the leachate is also influenced by the amount and type of degradation that is occurring and the quality of the incoming moisture. Biological decay within the landfill generates organic acids and carbon dioxide, both of which tend to reduce the pH of water, making some waste constituents (i.e., metals) more mobile. Typical landfill leachate characteristics are presented in the following table:

Typical Leachate Characteristics

Constituent	Range (mg/L)
BOD (5-day biochemical oxygen demand)	2,000 - 30,000
TOC (Total Organic Carbon)	1,500 - 20,000
COD (Chemical Oxygen Demand)	3,000 - 45,000
Total Suspended Solids (TSS)	200 - 1,000
Organic Nitrogen	10 - 600
Ammonia Nitrogen	10 - 800
Nitrate	5 - 40
Total Phosphorus	1 - 70
Ortho Phosphorus	1 - 50
Alkalinity as CaCO ₃	1,000 - 10,000
pH	5.3 - 8.5
Total Hardness as CaCO ₃	300 - 10,000
Calcium	200 - 3,000
Magnesium	50 - 1,500
Potassium	200 - 2,000
Sodium	200 - 2,000
Chloride	100 - 3,000
Sulfate	100 - 1,500
Total Iron	50 - 600

Movement of Leachate:

Leachate moves through the fill when a condition known as "field capacity" has been reached. Field capacity is the amount of free moisture a soil or refuse material can hold against the force of gravity. A good analogy for field capacity is the maximum amount of moisture an unsqueezed sponge can hold without dripping. When that amount is exceeded, moisture (leachate) can move downward by gravity.

Note: Field capacity is not the same as saturation. When a soil or waste material is saturated, all the void spaces between the soil or waste particles are filled with moisture. The soil does not have to be saturated for leachate to move through it by gravity. These concepts are illustrated in Figure 6A-2.

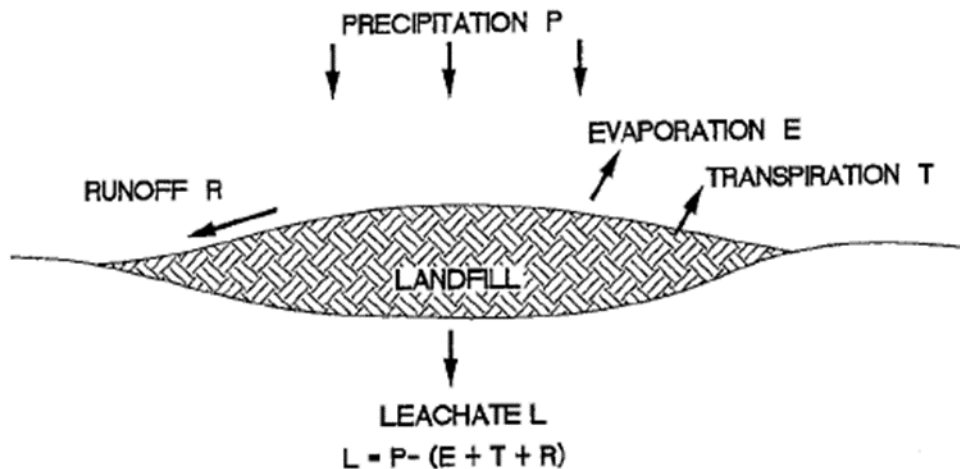


FIGURE 6A-1 :LANDFILL WATER BUDGET

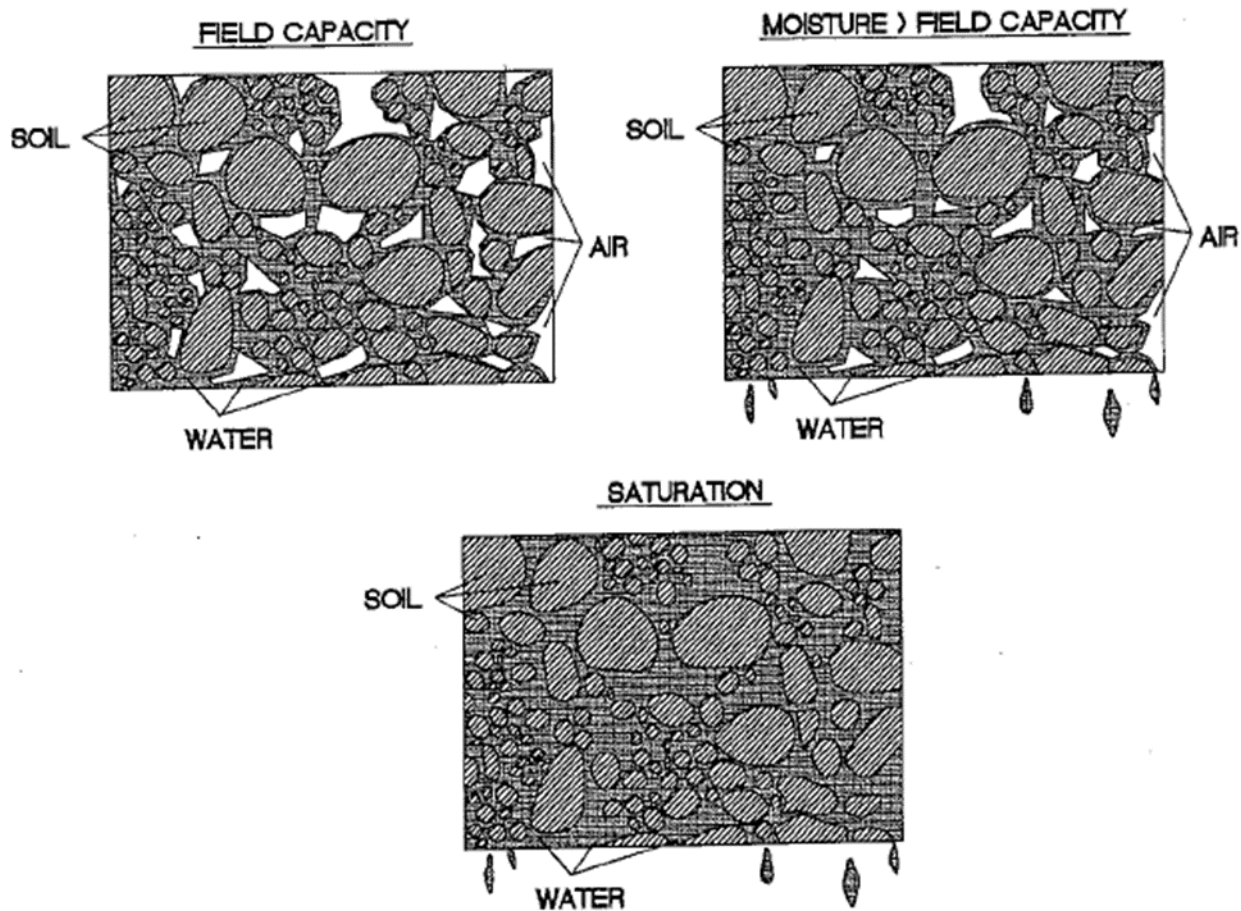


FIGURE 6A-2 :SOIL MOISTURE

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Leachate Migrates:

- downward in waste or soil pores after field capacity has been reached
- along channels through spaces in the soil or waste
- along the path of least resistance
- to the ground surface (along slopes or toe seeps) or
- to local ground water or surface waters

Why is leachate movement a concern? When leachate moves in the subsurface it has the potential to discharge at the surface and present a hazard, or intersect ground water or surface waters and become a source of water contamination.

Landfill Settlement:

Since some waste decomposition occurs at all landfills, so does land settlement and the problems that it may cause. Settling can ruin the integrity of the final cover system, allow water to enter the fill through ponding, and increase overall gas and leachate generation. There are two (2) kinds of settlement that occur at landfill sites: subsidence and differential settlement.

Subsidence is the uniform settling or sinking of the entire fill slowly with time. Subsidence reduces the height of the fill and is caused by:

- volume reduction due to waste decomposition
- long term compression from the weight of the fill materials
- poor compaction

Differential settlement is the non-uniform sinking of selected areas. Differential settlement reduces the height of the fill to a varying degree in different areas. Differential settling may occur in locations where:

- waste types with different decomposition characteristics have been buried in close proximity. For example, when highly degradable organic wastes are buried next to inert materials
- the degree of compaction varies, such as in high traffic areas compared to neighboring areas
- the fill depths are uneven

The amount of settlement (differential and subsidence) that occurs can depend on several factors:

- rate of decomposition

- amount of compaction
- type of refuse
- moisture content
- depth of refuse
- superimposed loadings, such as buildings

Potential Visual Indicators of Landfill Settling:

- standing water
- cracks and holes in the landfill cap/cover

Decomposition Control:

Since waste decomposition is the primary driving force behind landfill settlement and the generation of gas and leachate, decomposition control is an essential part of landfill management. We can use our knowledge about varying rates of decomposition to operate landfill facilities in a way that will help minimize differential settling. For example, choosing to compact inorganic wastes tightly around bulky waste areas may reduce differential settling at those locations.

Landfill operating practices are generally intended to minimize waste decomposition by creating a "dry tomb" for the wastes. Moisture is necessary for any biological decay and oxygen is necessary for the most rapid phase of biological decomposition. The best way to limit decomposition, then, is to eliminate moisture and oxygen.

Operating Practices for Decomposition Control:

- good compaction - excludes oxygen and limits water infiltration
- restriction on liquid disposal - minimizes moisture
- control surface water run-on - minimizes moisture
- adequate cover - excludes oxygen and limits water infiltration
- vegetated cap design - limits water infiltration

PART B. THE GROUNDWATER MONITORING PROGRAM

The purpose of groundwater monitoring at solid waste landfills is to identify any groundwater contamination which may occur as a result of leakage from the facility. Through regular groundwater monitoring, it is hoped that any contaminants will be identified before they present a significant environmental problem which may require a costly cleanup.

Where and When is a Groundwater Monitoring Program Required?

All landfills are required to monitor groundwater on a regular basis. Initially, at least four (4) quarterly samples must be collected to establish baseline concentrations, but ongoing detection monitoring is generally conducted semiannually.

Groundwater Monitoring Requirements:

The groundwater monitoring program will include **detection** monitoring and, if evidence of contamination occurs, may also include **assessment** and **corrective action** monitoring. Detection monitoring for the constituents in Chapter 2, Appendix A and C of the Solid Waste Rules and Regulations is conducted quarterly for one (1) year to establish baseline and/or background concentrations. After background groundwater quality conditions have been characterized, a statistical evaluation is performed to determine if there may be statistically significant differences between background and downgradient groundwater quality. Provided there are no statistically significant differences, a facility is required to establish semiannual detection monitoring for the Appendix A and C constituents. From then on, statistical evaluations must be conducted within 30 days following completion of each semiannual sampling and analysis event.

If any of the statistical evaluations reveal a significant difference between downgradient and background groundwater quality, then the facility must begin assessment monitoring within 90 days unless, within this 90-day period, the owner/operator successfully demonstrates that the differences between background and downgradient groundwater quality are due to a source other than the landfill, an error in sampling and/or analysis, an error in statistical evaluations, or natural variation of groundwater quality.

The Groundwater Monitoring System:

The groundwater monitoring system must include the correct number, placement and design of monitoring wells and must be approved by the DEQ prior to well construction. The number and construction details of the monitoring wells must be sufficient to identify any contaminants which may leach from the landfill to the uppermost aquifer. The uppermost aquifer is defined as “the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically connected with this aquifer within the facility’s property boundary.”

The groundwater monitoring system should contain a sufficient number of wells to monitor groundwater downgradient of the landfill (the downgradient side of a landfill will be the side toward which groundwater flows). At least one (1) well should be

located upgradient to allow measurement of the site-specific groundwater flow direction and to allow monitoring and characterization of background groundwater quality. Note that all well placements must be approved by the DEQ and that downgradient wells must be located no more than 150 meters (492 feet) from the waste management unit boundary on land owned, leased, or otherwise controlled by the landfill operator. Monitoring wells must also be designed and constructed in accordance with the Wyoming Water Quality Rules and Regulations.

A large number of factors need to be considered during design and construction of a groundwater monitoring system and monitoring wells. These factors are discussed in detail in a number of publications including *Recommended Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM, 1989); *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells* (Aller, et.al., 1989); *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (USEPA, 1986); *Groundwater and Wells* (Driscoll, 1986); and *RCRA Groundwater Monitoring Draft Technical Guidance* (USEPA, 1992). Several of the most important considerations to be made when installing a landfill groundwater monitoring system are summarized as follows:

- Landfill monitoring wells need to be located downgradient of active and reclaimed areas. Depending on facility layout, the DEQ may approve a well network that targets the whole landfill, rather than individual waste disposal trenches. The landfill site history, design and layout (number, spacing and orientation of individual disposal areas) should be evaluated to be certain that well locations provide adequate downgradient coverage. The number and location of downgradient monitoring wells should also account for seasonal changes in groundwater flow direction and flow rate. An example map showing the locations of properly placed monitoring wells is presented as Figure 6B-1.
- Monitoring wells should be constructed so that the water table remains within the intake screen interval (openings through which groundwater enters) during seasonal variations of the water table elevation. This will allow year-round collection of uppermost groundwater which is likely to be impacted first in the event of leachate release. Typical construction details of a properly constructed monitoring well are shown on Figure 6B-2.
- Aquifer sediments should be evaluated for thickness, grain size, heterogeneity and presence of aquitards or confining layers to be sure that screen slots and filter pack material are appropriately sized.
- The type(s) of waste accepted at individual disposal areas should be considered in order to account for differences in the fate and transport characteristics of associated contaminants.
- New monitoring wells should be thoroughly developed to ensure that they yield representative groundwater samples. Thorough development is typically accomplished using various techniques including bailing, swabbing, surging and pumping. If practicable, development should be conducted until each new well yields relatively clear, sediment-free water.

Sampling and Analysis Procedures:

Sampling and analysis procedures appropriate for your landfill will be specified in your Sampling and Analysis Plan (SAP). The SAP will describe the techniques used to measure water levels in the wells, collect and care for the groundwater samples and conduct the laboratory analyses. These sampling and analysis procedures must be approved by the DEQ and must be maintained as part of the facility permit application.

Personnel who are responsible for collection of groundwater samples must read and understand the SAP. All persons responsible for groundwater sampling must also have a working knowledge of appropriate groundwater sampling procedures. Contact the DEQ with any questions. At a minimum, members of the groundwater sampling team should be familiar with:

- sampling schedule/frequency
- sampling locations
- field measurements
- sampling procedure(s) Sampling constituents, analytical methods and containers type/size
- QA/QC procedures and samples, including sample preservation and holding times

These key pieces of information may be summarized in a **sampling matrix** (see Table 6B-1). If any of these pieces of information are missing from the SAP or if they are not clearly understood, then the person or company who wrote the SAP should be asked to clarify the issue.

After reading and understanding your SAP, it is helpful to think about the sampling project in terms of each major step. These steps will typically include:

1. ordering and preparation of sample containers
2. preparation of equipment and decontamination
3. instrument calibration and operation
4. water level measurements and purging the wells
5. sample collection and field analyses
6. sample preservation, documentation, custody control, and shipment

Ordering and Preparation of Sample Containers:

The laboratory conducting the analyses should provide sample containers of the appropriate type and size, container labels, sample preservatives, and documentation forms as part of routine laboratory services. The following elements should be incorporated into your container request to be sure that the correct containers are shipped and delivered:

- fax or send a copy of the sampling matrix to your laboratory representative so that they can review it prior to shipping the containers and go over any questions they may have regarding the shipment
- request that the laboratory provide sample containers, preservatives, QA/QC and results report in accordance with EPA analytical methods listed in the sampling matrix
- request that the bottles be delivered with preservatives and labels already in place and that custody records and custody seals be provided
- request that the bottles be shipped in coolers that are packed as though the samples were already collected (packing material already in place and space for ice or blue ice provided) - specify bubble wrap and/or foam - steer clear of Styrofoam packing peanuts
- request that the coolers and containers be delivered a few days prior to the scheduled sampling so that there is time to inspect the containers and rectify any problems with the order
- upon receipt of the coolers, carefully unpack and inspect the containers to be sure the order is complete, undamaged, and that containers and preservatives match the sampling matrix

Preparation of Sampling Equipment and Decontamination:

After verifying that the container order is complete, you will be ready to move to the field activities. It is a good idea to use a water-proof field notebook and equipment check list that match your sampling methods, analytical requirements and QA/QC procedures. Some of the items you need to conduct the sampling project will be available at a grocery store and/or hardware store. After checking your equipment inventory, you will be ready to proceed to the field and set up the decontamination station.

The decontamination station should include a **detergent wash**, **tap water rinse** (optional), **distilled-water rinse** and **virgin distilled water rinse**. Insulated containers such as 10 or 20 gallon water coolers work well for decontamination because they have tight fitting lids and will keep your decontamination water from cooling off and freezing. The station should be set up on pallets or plastic to prevent the area from becoming muddy and sloppy and to provide a clean work surface for the decontaminated equipment.

After the decontamination station is set up, all equipment that will come in contact with the laboratory samples should be thoroughly decontaminated. To avoid cross-contamination of samples, each piece of equipment must be decontaminated prior to use at each well. It is also important to disassemble equipment components as much as possible during decontamination to thoroughly remove contaminants. If not dedicated to a single well, special attention must be given to sample collection devices such as pumps and bailers.

Instrument Operation, Calibration and Documentation:

The field instruments you are likely to use include water level, pH, temperature, and conductivity meters. It is usually best to have most other parameters and constituents analyzed at the laboratory. When renting or purchasing field instruments, it is usually best to select those that are easy to maintain and calibrate. It is also very important to read and understand each manufacturer's instructions (call to ask questions if uncertain how to properly calibrate and operate the instrument). When using field instruments, it is important to document instrument calibration activities and results in your field notebook as part of routine field quality assurance protocol.

Water Level Measurements and Purging the Wells:

Appropriate protocol must be used for collecting water level measurements and purging the wells prior to sampling. Important items to remember include instrument calibration and accuracy checks, equipment decontamination, and accurate determination and removal of three well volumes of water (wells that are slow to recover can simply be purged to dryness prior to sampling). It is also important to minimize agitation of the water column during purge operations. Field observations and field water quality data (temperature, pH, specific conductance, silt content, color, odor, sheen, etc.) should be documented in your field notebook after each well volume is removed.

Collection of Samples:

Procedures for sample collection are briefly summarized as follows:

- review the container filling order on the sampling matrix and place the container sets for the well(s) you will visit consecutively into a cooler with ice and temporary packing
- be sure to decontaminate all sample collection equipment

- use bailer(s) or sampling pump(s) to collect samples from the center of the water column in each well, taking care to minimize agitation and aeration of the water and samples
- fill each container directly from the sampling bailer or sample pump line - do not use intermediate containers of any kind
- be careful to avoid overfilling containers - this can cause loss of the preservative
- Do not under fill containers - head space should be minimized and should be zero if analyzing for volatile organic constituents
- wipe filled containers clean and add the date and time of sample collection to the sample labels
- place the filled sample containers back in the cooler with adequate packing material and ice to return to the location where sample inventory, documentation and final packing will be conducted

Sample Documentation, Custody Control, and Shipment:

If possible, most of this work should be completed in a clean area or room where climatic conditions are favorable. The steps that should be taken when completing analytical request forms and preparing the samples for shipment include:

- review the sampling matrix and be sure that filled containers match the matrix and that there are no missing or damaged containers
- make sure all container labels are legible and fill in any missing information
- make sure all necessary field sampling information is adequately documented in the field notebook
- fill out the analytical request form/custody record provided by your lab - be sure the form is complete and attach a copy of your sampling matrix so that the analytical request is clear; if you are uncertain about the information or blanks on the form then call the lab for clarification
- repack the sample containers into the coolers and renew the ice supply so that the sample temperature will stay at or below 4°C - be careful to protect the coolers from freezing; when packing, a good rule of thumb is to fill the coolers with about 1/3 sample containers, 1/3 packing material and 1/3 ice
- try to pack soft containers in between hard containers and try to keep the container sets for each well together as much as possible
- try to use blue ice or put ice cubes inside double bags to eliminate water in the coolers
- sign and date the custody record, and place the completed form inside a plastic bag so that it won't get wet - be sure to specify the total number of coolers that are in your shipment
- sign and attach the custody seals and attach them to the coolers - use packing tape or fiberglass tape to seal the lid of each cooler
- complete shipping labels and secure them to the outside of the coolers

- if possible, use an overnight delivery service or other 24-hour courier to ensure that samples arrive on time and that sample holding times are met - it is usually best to ship samples on Monday through Thursday so that they don't have to sit over the weekend
- following shipment, call the lab to make sure samples arrived safely and on time and remind the lab representative of your name and phone number in case questions come up

Sampling and Analysis Schedule:

Your sampling and analysis plan (SAP) should specify the frequency of sampling and the list of constituents to be monitored during each event. The sampling and analysis schedule should also specify the type of monitoring associated with each well (detection, assessment and/or corrective action monitoring). Note that all three types of monitoring can be ongoing at the same facility. Monitoring types are illustrated in the flow chart on figure 6B-3. Each of these types of monitoring is briefly described below.

Detection Monitoring:

Facilities must institute a detection monitoring program which includes sampling of each well semiannually and testing each sample for the constituents in Chapter 2, Appendix A and C of the Solid Waste Rules and Regulations (see Figure 6B-3). Under certain circumstances, the DEQ may reduce the sampling frequency to annual.

Assessment Monitoring:

Assessment monitoring is required whenever a statistically significant increase in a contaminant concentration over background water quality level has been detected and not shown to be related to a source other than the landfill. Under assessment monitoring, the owner/operator is initially required to collect a sample from each downgradient well and analyze the samples for the constituents listed in Chapter 2, Appendix B of the Solid Waste Rules and Regulations. Sampling for Appendix B constituents is required within 90 days of triggering the assessment monitoring requirement. The requirement to commence assessment monitoring can be waived only if the owner/operator successfully demonstrates that the statistically significant difference between background and downgradient groundwater quality is due to a source other than the landfill, an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Such demonstration must be made within 90 days after the statistically significant difference is identified.

If Appendix B constituents are detected during the initial assessment monitoring event, then the owner/operator must promptly collect four (4) additional independent

samples from each background and downgradient well and analyze the samples for each Appendix B constituent which was detected during the initial event.

Data from the four (4) additional independent sampling events must be used to establish background concentrations for each detected Appendix B constituent so that statistical comparison to background concentrations and/or the groundwater protection standards can be made. If such statistical comparisons reveal that concentrations are above background but below groundwater protection standards, then assessment monitoring for those constituents continues until such time as concentrations are statistically below background for two (2) consecutive events. During assessment monitoring, all Appendix B constituents specified by the DEQ must generally be analyzed at least annually.

If statistical evaluations indicate that concentrations of Appendix B constituents are above background and groundwater protection standards, then the landfill owner or operator is required to continue assessment monitoring and establish a corrective action program for the contamination. Elements and objectives of the corrective action program will be to stop the release and clean up groundwater contamination. A corrective action program could include additional assessment, additional monitoring, waste removal, waste stabilization, and environmental clean-up work such as pumping and treatment of groundwater.

Statistical Evaluation of Analytical Data:

Statistical evaluation of groundwater data is necessary to determine whether landfill leachate may be impacting groundwater. Results of the statistical analysis of the groundwater data are the basis for moving from the detection monitoring program to the assessment monitoring program and are used to determine the need for and scope of corrective action.

Statistical evaluation of analytical data during detection or assessment monitoring should be conducted by a qualified engineer or scientist using statistical methods approved by the DEQ. The permit application must provide a description of the statistical methods that will be used to evaluate groundwater quality. Statistical tests are to be conducted separately for each constituent in each well.

Operators must submit groundwater monitoring data in an electronic format specified by DEQ.

SECTION 6. LANDFILL MONITORING AND REPORTING

Table 6B-1. Example Groundwater Sampling Matrix.

LANDFILL: Your Town Municipal

MONITORING PROGRAM: Semiannual Detection Monitoring

DATE: _____

PERSONNEL: _____

SAMPLE COLLECTION REQUIREMENTS:

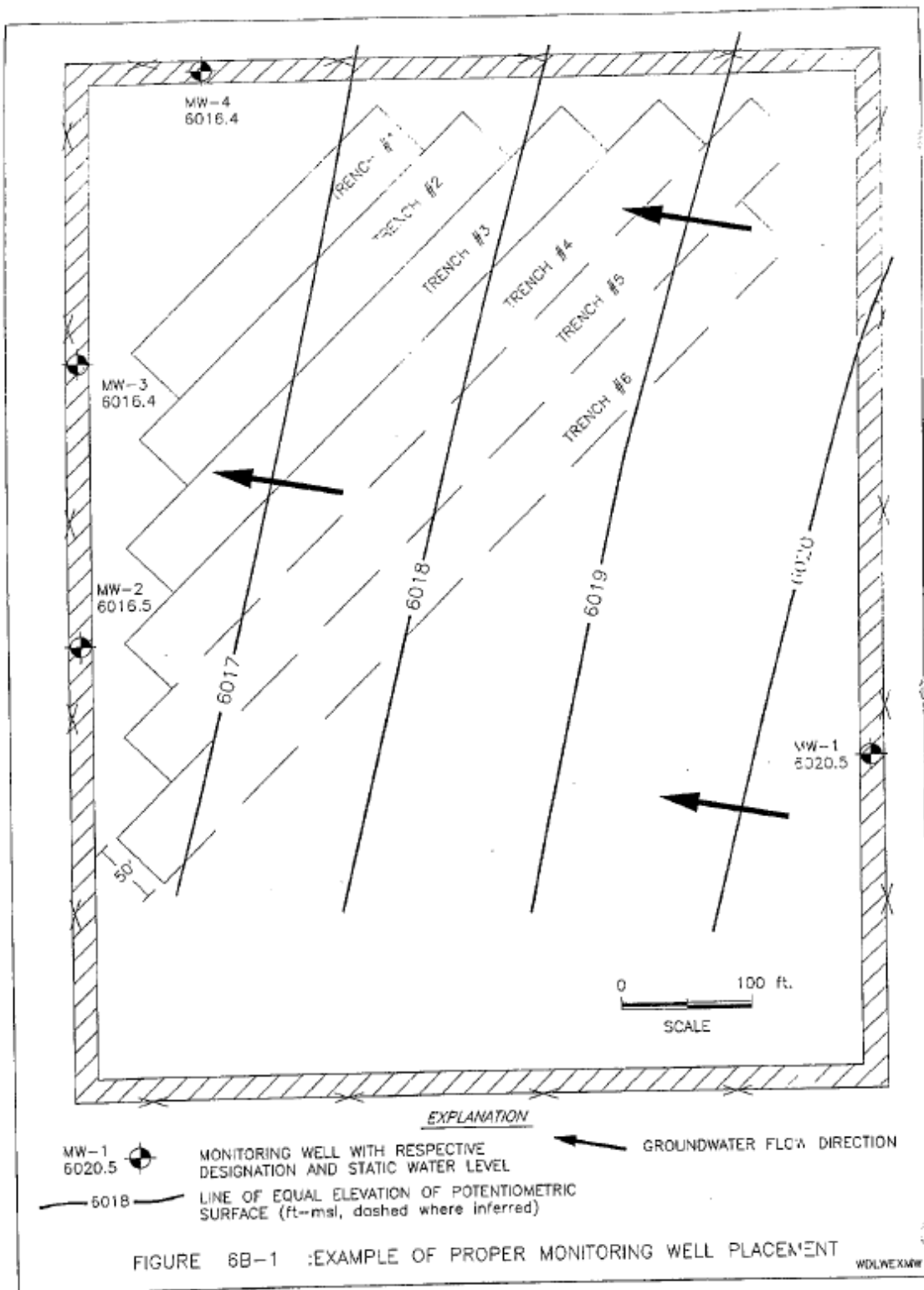
WELL	TYPE	FIELD PARAMETERS	VOLATILE ORGANIC COMPOUNDS	TOTAL METALS	NUMBER OF CONTAINERS
MW-1	background	Y	Y	Y	3
MW-2	background	Y	Y	Y	3
MW-3	downgradient	Y	Y	Y	3
MW-4	downgradient	Y	Y	Y	3
MW-5	downgradient	Y	Y	Y	3
MW-6	downgradient	Y	Y	Y	3
QA/QC Duplicate	n/a	N	Y	Y	3
QA/QC Field Blank	n/a	N	Y	Y	3
QA/QC Trip Blank	n/a	N	Y	N	2

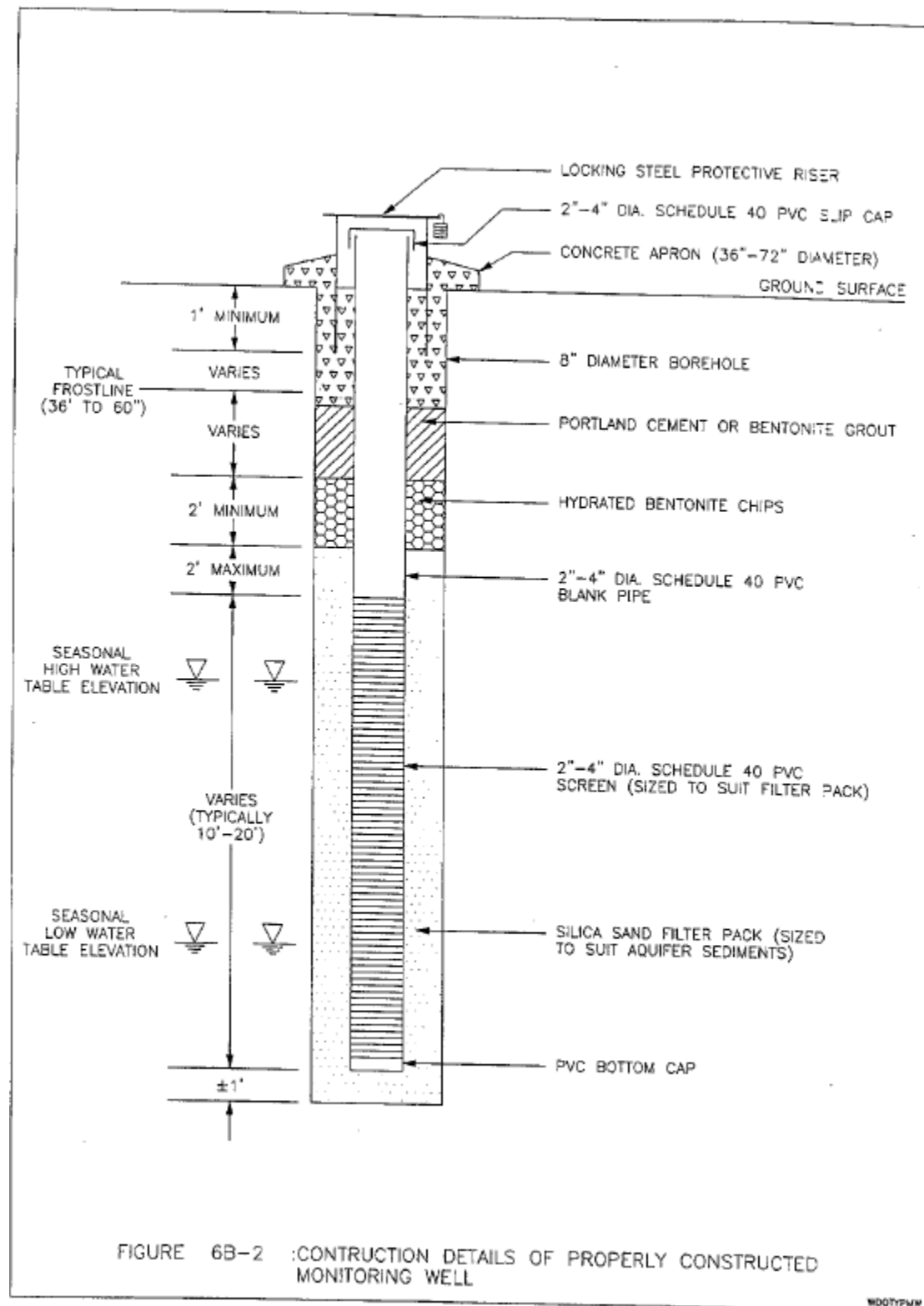
ANALYTICAL METHODS, CONTAINERS, PRESERVATION AND HOLDING TIMES:

CONSTITUENT	SW-846 METHOD NO.	CONTAINER	PRESERVATION	HOLDING TIME	TARGET REPT. LIMIT
Field Parameters					
Temperature	Field Meter	n/a	n/a	n/a	n/a
pH	Field Meter	n/a	n/a	n/a	n/a
Specific Conductance	Field Meter	n/a	n/a	n/a	n/a
Metals					
Antimony, total	7041	1 L Plastic	4°C, HNO ₃ (pH < 2)	6 mos.	0.006 mg/L*
Arsenic, total	7060	same	same	same	0.01 mg/L
Barium, total	6010	same	same	same	0.02 mg/L
Beryllium, total	6010	same	same	same	0.003 mg/L
Cadmium, total	7131	same	same	same	0.001 mg/L
Chromium, total	6010	same	same	same	0.07 mg/L
Cobalt, total	6010	same	same	same	0.07 mg/L
Copper, total	6010	same	same	same	0.06 mg/L
Lead, total	7421	same	same	same	0.01 mg/L
Nickel, total	6010	same	same	same	0.05 mg/L
Selenium, total	7740	same	same	same	0.02 mg/L
Silver, total	6010	same	same	same	0.07 mg/L
Thallium, total	7841	same	same	same	0.002 mg/L*
Vanadium, total	6010	same	same	same	0.08 mg/L
Zinc, total	6010	same	same	same	0.02 mg/L
VOCs (see att. list)	8260	40 mL vial (2)	4°C, HCl (pH < 2)	14 days	0.005 mg/L

* Target Reporting Limit is lower than Practical Quantification Limit specified for Method No.

SECTION 6. LANDFILL MONITORING AND REPORTING





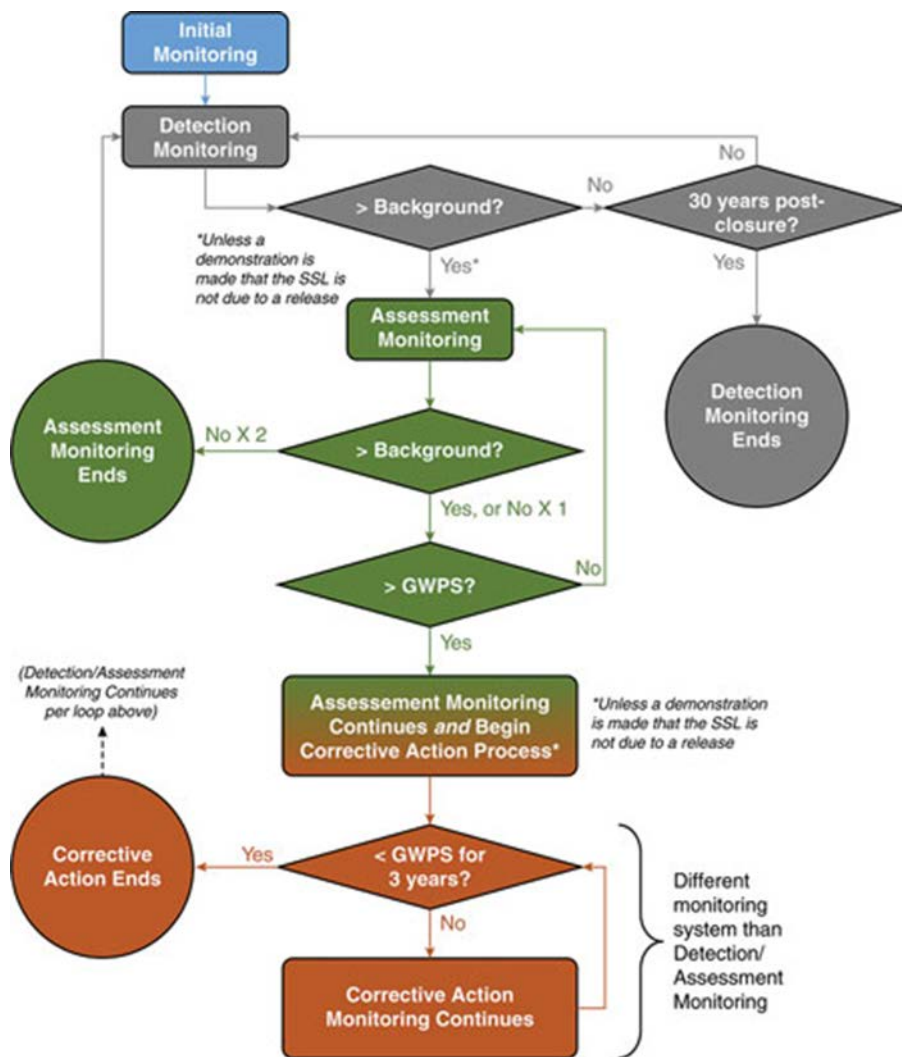


Figure 6B-3

Detection, Assessment and Corrective Action Monitoring

PART C. THE METHANE MONITORING PROGRAM:

Methane gas produced by decomposing solid wastes can become an explosion hazard (see Section 6A - Solid Waste Decomposition). Methane monitoring is conducted to ensure that elevated methane concentrations are detected before they present an explosion hazard to landfill workers and the general public. The primary goal of the methane monitoring program is public and worker safety. Wyoming's landfill regulations require that landfill operators:

- monitor methane at the facility boundary
- monitor methane inside any on-site buildings
- conduct methane monitoring at least quarterly
- control methane below the lower explosive limit (LEL) at the facility boundary and 25% of the LEL in buildings

What is the Lower Explosive Limit?

The Lower Explosive Limit (LEL) for any gas is the lowest concentration of that gas in air that can result in an explosion if an ignition source is present. The LEL for methane is 5% in air (by volume). When this critical concentration of methane is reached, we say that 100% of the LEL has been reached and that there is immediate concern that an explosion could occur, particularly if the concentration develops inside a building or other confined space where ignition sources could be present. When methane concentrations are below 100% of the LEL (concentration is still less than 5% in air), then there is not enough methane in the air to create an explosion hazard. Concentrations of methane that fall between the LEL and the Upper Explosive Limit (UEL) are explosive whenever there is an ignition source.

What is the Upper Explosive Limit?

The UEL is the highest concentration of gas that will cause an explosion if an ignition source is present. The UEL for methane is 15% in air (by volume), or 300% of the LEL. At methane concentrations above the UEL, the methane concentrations are so high (also called rich) that there is insufficient oxygen to cause an explosion hazard. However, this situation can change rapidly if air or oxygen are introduced, or if the methane concentrations drop. Therefore, any concentration of methane that approaches or exceeds the LEL is considered dangerous.

How Do You Read a Methane Meter?

Methane concentrations are measured using portable gas detection instruments, usually a methane meter or explosimeter which has a readout in either %LEL or % by Volume. That means that if you have a meter that reads in %LEL, gas levels less than 25% are within the regulatory limit. If the meter reads in % by Volume, then only gas levels less than 1.25% are within the regulatory limit. A table showing the appropriate conversion between %LEL and % by Volume is shown below.

Equivalent Methane Gas Measurements (*Explosive Concentrations)

%LEL	%Volume	%LEL	%Volume
0	0	25	1.25 (regulatory limit)
1	0.05	50	2.5
5	0.25	100	5.0
10	.050	300	15.0
20	1.00	400	20.0

Methane Monitoring Tip:

Many methane meters have two (2) scales, one (1) for detecting trace amounts of methane and one (1) for detecting higher concentrations. Sometimes the low range scale operates by a different mechanism than the high range scale, requiring combustion of gas in order to function properly. If methane levels are high, the low range scale may indicate 0% methane because the combustion mechanism is simply not working. To avoid misreading the meter, always take a reading using the high range scale first. Switch to the low range scale for more precise results when the initial readings indicate that methane levels are low. Similarly, if you are using a combustible gas indicator with an oxygen meter, be aware that at least 10% oxygen is necessary for the combustible gas indicator to work properly.

Where Must You Monitor for Methane?

Check your landfill operating plan for the locations of permanent methane monitoring points. Perforated wells placed around the site perimeter and near any on-site buildings usually provide the primary sampling points for a landfill gas monitoring system. These permanent test wells allow you to test soil for methane on a routine basis (usually quarterly) with relatively uniform test conditions. The atmosphere within any on-site building, particularly any basements or crawlspaces, must also be monitored for methane accumulation if they are not supplied with continuous monitoring and alarm systems. Simply follow the testing protocol outlined in the procedures section below.

Where Else Should You Monitor For Methane?

Although not specifically required by law, it is also advisable to check the following locations for build-up of methane gas:

- monitoring wells
- conduits
- manholes
- trenches
- leachate collection systems
- methane vent systems
- any other on-site structures that could collect landfill gas
- areas of stressed or dead vegetation
- soil cover

In Summary, the Main Components of the Methane Monitoring Program Are:

- permanent sampling locations at the landfill perimeter - data from these locations can be used to demonstrate compliance with the maximum LEL limit at the facility boundary and provide evidence that methane is not migrating off-site to any significant extent
- defined sampling locations within on-site buildings (unless the buildings are equipped with a continuous monitoring and alarm system) - data from these locations can be used to demonstrate compliance with the maximum 25% LEL limit within on-site buildings and verify a safe working environment
- optional sampling locations, temporary or permanent, based on general safety concerns and operator judgement (suggested locations near on-site buildings and others listed above)

How Can You Quickly Collect Methane Measurements from the Subsurface?

Methane well construction is illustrated on Figures 6C-1 and 6C-2. While not illustrated on the figures, the sampling ports on the wells should be equipped with a valve/port that can be closed or shut off when samples are not being collected. It is important that the measuring device be sealed from ambient air at the surface to prevent dilution. Methane monitoring wells should be completed to the base of waste. Care should be taken to prevent water or moisture from entering the methane meter; in-line traps can be installed between the meter and the monitoring probe or stake to prevent this.

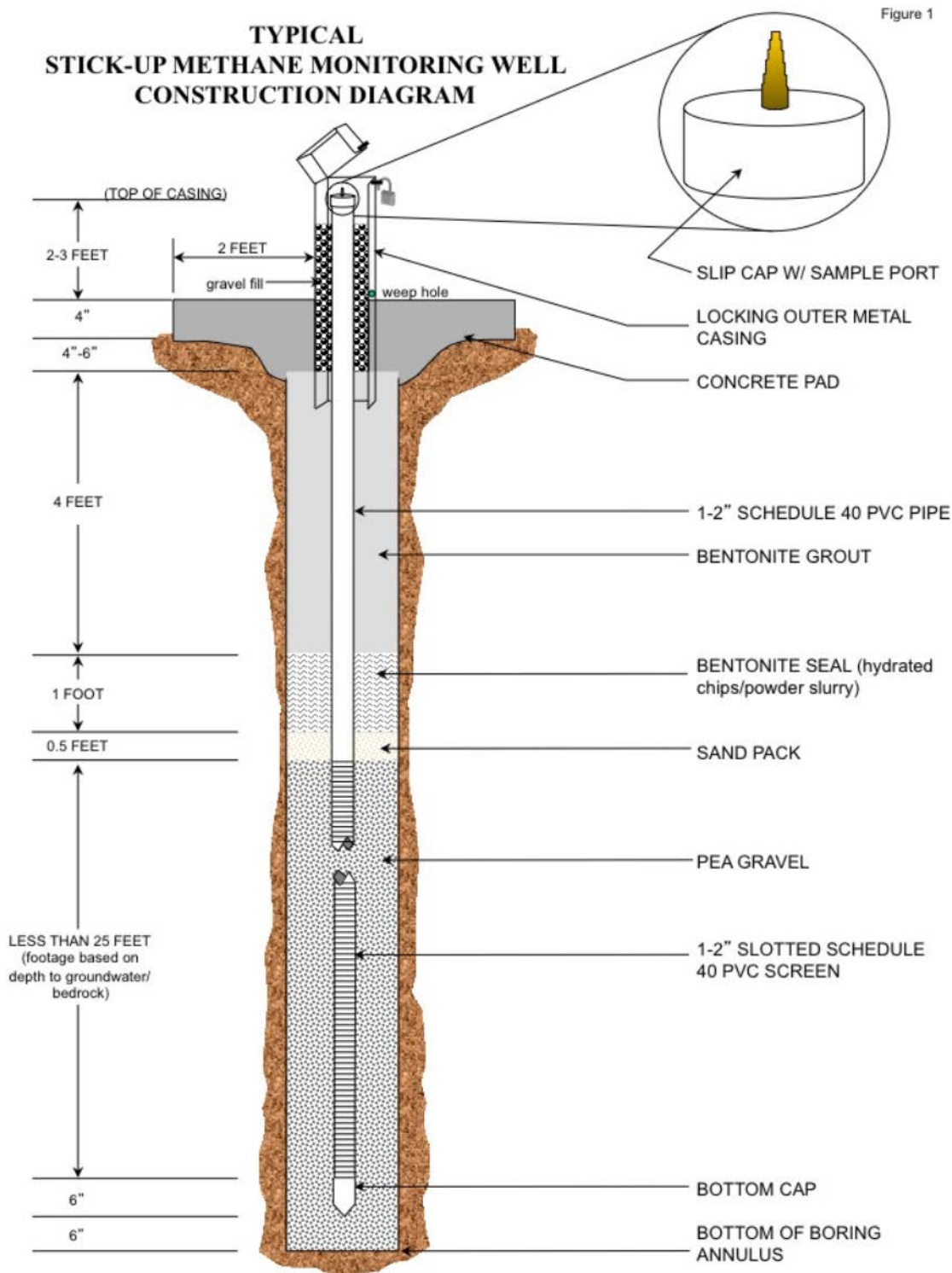


Figure 6C-1

Figure 2

TYPICAL FLUSH-MOUNT MEHTANE MONITORING WELL CONSTRUCTION DIAGRAM

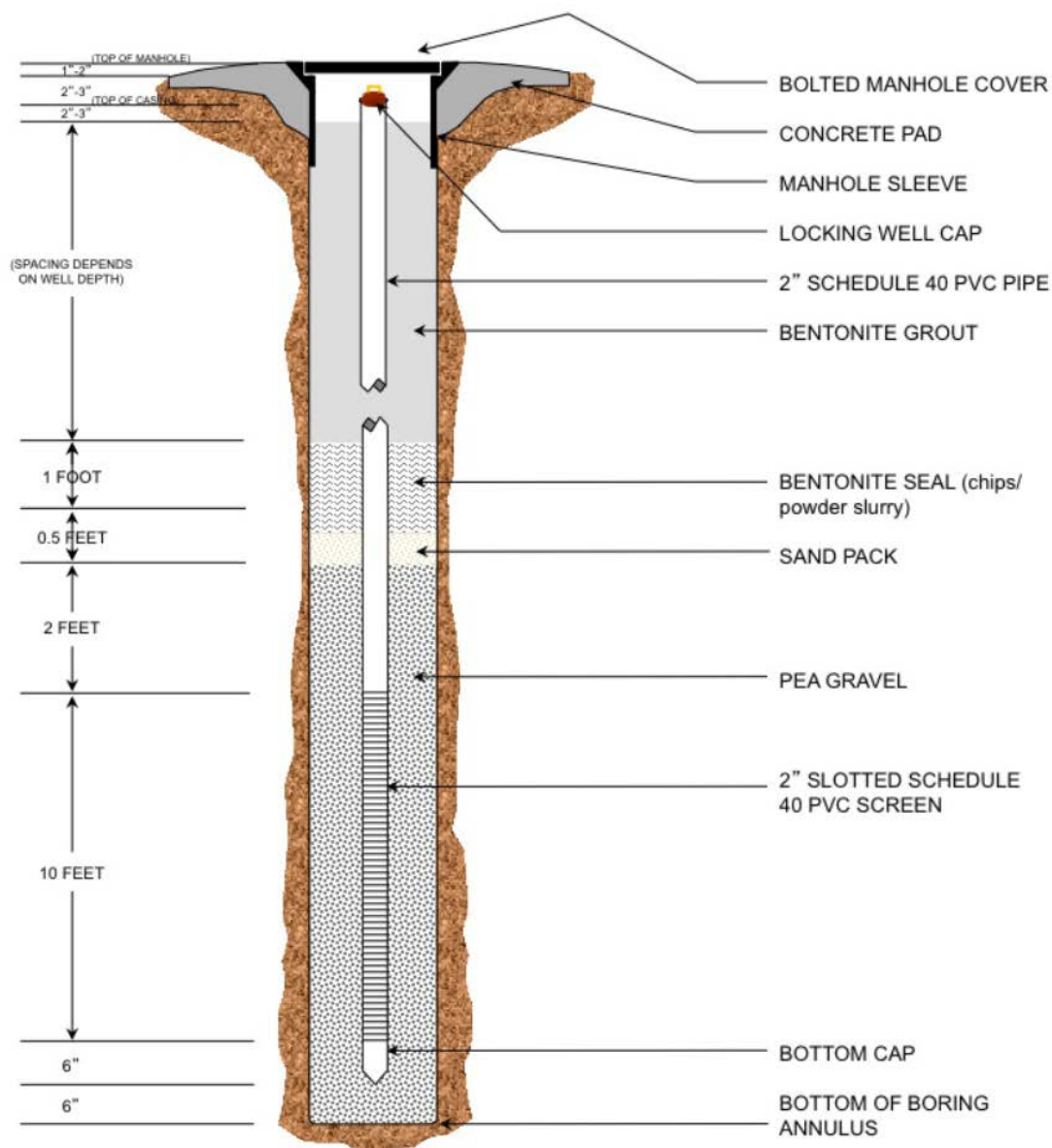


Figure 6C-2

When is a Good Time to Measure Landfill Gas?

Local climatic conditions can affect the level of gas measured at the time that methane monitoring is conducted. For example, low barometric pressure may cause landfill gas to expand and rise in the landfill while high barometric pressure may cause landfill gas to compress. You are likely to detect maximum methane levels if you elect to conduct methane sampling:

- just after a low pressure system like a thunderstorm has passed through the vicinity. Gases will rise through the landfill more readily at that time
- during extended periods of snow cover or freezing temperatures since gases may buildup in the subsurface below the frost line or in enclosed spaces.

Methane Monitoring Procedures:

The specific methane monitoring protocol and locations applicable to your landfill will be described in your permit application/SAP. The general steps that you will follow are listed below:

1. Check that the batteries in the combustible gas meter are fully charged. Many meters will be equipped with a battery charge indicator
2. Check the instrument for leaks in the pump circuit and repair if necessary. You can check for leaks by attaching all hoses, probes and other air-drawing devices to the instrument and then blocking the gas inlet opening(s) with your finger or tape. After blocking the inlet openings, operate the pump or squeeze the aspirator bulb. A leak-free bulb will remain collapsed and a pump will labor (don't let it labor too long to avoid damage)
3. Calibrate the meter in accordance with manufacturer's instructions. Calibration should be conducted before and after each day's round of sampling and more frequently if your measurements are unusual or you are uncertain if the meter is functioning properly. When calibrating your instrument, use only the equipment and procedures recommended by the manufacturer and use only certified calibration check gas at the recommended concentration
4. Obtain representative samples by placing the inlet end or probe in the sampling device or atmosphere to be sampled and either operate the aspirator bulb at least five (5) times, or if equipped with a pump, look for needle deflection or steady-state meter readings, typically within 30 seconds after pumping begins
5. Read the meter and record the maximum percentage of the LEL that you observed (see Meter Reading above)
6. Notify landfill manager and the DEQ immediately if any measurement exceeds the LEL at the facility boundary or 25% of the LEL in a building
7. Before monitoring the next location, purge the instrument with clean air by aspirating the bulb five (5) times or by pulling in clean air until the needle drops back to zero and is stable

How Do You Report Your Data?

Transcribe the readings you obtain from your monitoring instrument (methane meter/explosimeter) in the field and enter the information on the appropriate methane monitoring report form. These forms are usually provided in an appendix to the approved landfill operating plan or SAP. Always be sure to indicate whether the readings are %Volume or %LEL. For locations within on-site buildings, be sure to record the exact location inside the building where the atmosphere was sampled. Use the same sampling location each time you perform routine monitoring so that results can be compared from time period to time period.

Be sure to place a record of the results of all analyses (original methane monitoring report forms) in the facility operating record to be available for review by the DEQ. The results must also be reported to the DEQ as specified in your operating permit. The report summarizes and interprets the results of the methane monitoring program.

What Do You Do if your Data Shows Methane Levels above the Allowable Limit?

Always compare your data with the regulatory limit and immediately notify the solid waste manager if you believe that your data indicates that the limit has been exceeded. If the methane regulatory limit (the LEL at the facility boundary and 25% of the LEL in a building) has been exceeded at the facility boundary:

- immediately notify the DEQ
- immediately take steps to protect human health (such as limiting access, cordoning off the affected area, notifying adjacent property owners if imminent danger, etc.)
- within 7 days: place a copy of the methane test data in the operating record with a written description of steps taken to protect human health
- within 60 days, unless an alternate date has been approved by DEQ: implement a DEQ approved remediation plan and place a copy of that plan in the operating record

A methane gas remediation plan should include:

- a summary of the applicable methane data
- a discussion of the potential source and path of migration
- a proposed management plan or engineering design for methane control (see Section 5E - Methane Control Systems)
- a proposal for post-remediation methane monitoring and any other site-specific information requested by DEQ

There are some special concerns about high methane levels in indoor environments. High methane levels could cause exposure of workers to atmospheres lacking sufficient oxygen due to displacement of air by landfill gas. Workers could be exposed to high concentrations of hydrogen sulfide or other toxic gases whenever there is a high concentration of landfill gas (as indicated by high methane levels) in an indoor environment. In addition, ignition sources are more likely to be present inside a building, particularly one that houses any electrical equipment which can cause sparks. Explosions can be triggered by something as seemingly harmless as static electricity!

Remember! Methane explosions from landfill gas are not restricted to the wetter areas of the country - landfills in our arid Rocky Mountain region have had their share - Denver (1977) - 2 dead, 4 injured; Englewood, CO (1976)- 3 seriously injured.

SECTION 7
LANDFILL CLOSURE

SECTION 7

LANDFILL CLOSURE

TRAINING OBJECTIVES:

- 1) To provide landfill managers with a clear understanding of the regulatory closure standards that must be met for final covers, seeding and closure certification.
- 2) To explain the rationale and intent of the regulatory standards.
- 3) To familiarize landfill managers with methods and suggestions for complying with the regulatory standards.

PART A. GENERAL

Commencement of Closure:

Approved closure activities shall commence no later than thirty (30) days after the date on which each unit receives the known final receipt of wastes and shall be completed within one hundred eighty (180) days following commencement of closure. The DEQ may approve:

- Delayed closure of a facility or unit if the facility or unit has additional remaining disposal capacity, and the owner demonstrates that there will be no threats to human health or the environment from the unclosed facility or unit, and
- Extensions of the closure period if needed to adequately complete closure activities and the owner demonstrates that there will be no threats to human health or the environment from the unclosed facility or unit.

Note the difference between unit closure and facility closure. Individual disposal units need to be closed when they have reached capacity. When the entire landfill reaches capacity final cover may be needed over the last disposal unit and all other disturbed areas of the landfill must be reclaimed as specified in the approved permit application.

In general, a landfill designed with large disposal units/areas should be designed so that closure occurs in stages (see Figure 3L-3). Doing so spreads the cost of final cover out over the life of the unit, minimizes infiltration and leachate generation in areas with final cover, and reduces the amount of financial assurance needed.

Notification and Certification of Facility and Unit Closure:

Prior to the commencement of closure activities, the operator shall notify the DEQ in writing and place a notice of closure in the operating record. Following closure of each unit and facility, the operator shall submit a certification with supporting documentation signed by an engineer licensed to practice in Wyoming that closure has been completed in accordance with the approved closure plan and place a copy of the certification in the facility operating record.

Maintaining records of closure activities when they occur is very important because this will ensure that this information is available when closure of the entire facility must be certified by an engineer.

Notice on deed:

At facility closure, an instrument which clearly gives notice of the restrictions that apply to future activities on the disposal facility property shall be filed for recording by the registrar of deeds (county clerk) in the county where the facility is located. Wording of such an instrument shall indicate that the property has been used as a solid waste disposal facility. This shall be recorded prior to any property transaction resulting in another use for the property. The owner/operator, or its successors, shall ensure that post-closure use of the property will be restricted to prevent any disturbance to the facility's containment system including caps and liners, or the functioning of the facility's monitoring system. The owner or operator may request permission from the DEQ to remove the notation from the deed if all wastes are removed from the facility.

Closure Permit Applications:

A closure permit application must be submitted no later than 12 months prior to the date the facility is anticipated to cease disposal of waste unless an alternate schedule is approved by the DEQ for good cause.

In the event any solid waste management facility ceases operation, as determined by nonreceipt of solid wastes for any continuous nine (9) month period, the facility operator shall provide written notification to the DEQ no later than thirty (30) days after the end of such nine (9) month period. This notification shall be accompanied by a closure permit application unless the DEQ approves interim measures with delayed final closure for good cause upon application by the operator.

Closure permit applications must include the following:

- permit application form
- general information
- regional geology

SECTION 7. LANDFILL CLOSURE

- site specific geology
- design and construction information
- monitoring information
- recordkeeping information
- reporting information
- financial assurance information
- corrective action information (if applicable)
- transfer, treatment and storage information (if applicable)
- special waste information (if applicable)
- supporting documentation

Post-closure Land Use:

Each facility shall be returned to the post-closure land use specified in the permit, unless an alternative use is approved by the DEQ. See Section 8 for more post-closure information.

Closure Certification:

To ensure that closure has been completed in compliance with the closure plan and that the facility has been closed in compliance with the DEQ's closure standards, a certification from a Wyoming registered professional engineer is required at the completion of the closure activities.

At a minimum, the engineer's certification must include the following documentation:

1. Deed Notice

Provide a copy of the deed notice that was filed with the county clerk's office and the date of filing. If the facility is located on land leased from the BLM, provide a copy of the notation placed on the Master Title Plat.

2. Posted Notification

Provide a publisher's affidavit verifying that the closure notice has been published in an area newspaper.

3. Final Cover

Provide verification from soil borings, test pits, etc. that the compacted soil layer and the topsoil layer have been placed at the required thicknesses.

Provide the results of field density testing verifying that the construction

specifications have been met, thus ensuring that the minimum required permeability has been achieved. .

The locations of the soil boring, test pits and field density tests should be identified on a facility plot plan, preferably the facility's final contour map.

4. Engineered Containment System

If the facility has an engineered containment system, provide a copy of the construction quality assurance and quality control reports.

5. Final Contour Map

If the final contours of the site vary significantly from the final contour map in the approved closure permit application, provide an as-built of the final contour map.

6. Seeding

Provide a full description of reclamation activities, including the dates on which activities were completed. The description should include the methods and rates at which soil amendments, fertilizer, seed and mulch have been applied.

Copies of seed bag tags should be provided to verify seed mixtures. Copies of mulch certifications should be provided to verify "weed free" mulch.

7. Surveyed Corners

If not previously submitted, provide a plat and legal description signed by a Wyoming registered professional land surveyor, which identifies all corners with permanent survey caps.

8. Surface Water Diversion

If the location, design or construction of the surface water diversion system has been altered significantly from the system defined in the approved closure permit application, provide as-built maps, cross-sections and construction details.

9. Other Activities

Provide a detailed description of any other activities related to closure such as fencing, posting, etc.

10. Closure Certification

Provide a closure certification statement which is signed, dated and stamped by a Wyoming registered professional engineer.

PART B. FINAL COVER DESIGN

To minimize infiltration of moisture into the waste layers and to protect the final cover from erosion, owners/operators must install a final cover system over all filled areas. Final cover may consist of a conventional soil cap, an engineered containment system, or a water balance cover. The Solid Waste Rules require that final cover shall be designed and constructed to:

- have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present or a permeability no greater than 1×10^{-5} cm/sec, whichever is less
- minimize infiltration through the MSWLF by the use of an infiltration layer that contains a minimum of 18 inches of earthen material
- minimize erosion of the final cover by the use of an erosion layer that contains a minimum of 6 inches of earthen material revegetated to sustain native plant growth or an erosion layer that provides equivalent protection from wind and water erosion as approved by the DEQ
- compacted soil barrier layers forming a cap shall be overlain by a layer of soil which is of suitable thickness to protect the compacted soil barrier layer from frost penetration

The DEQ may approve an alternative final cover system design that includes an infiltration layer that achieves an equivalent reduction in infiltration as the layer specified in the first two bullets above. The DEQ may require monitoring of alternative final cover designs to demonstrate the performance of the designs.

The regulatory requirement for final cover is applicable to all areas which have received wastes after October 9, 1991. Areas which stopped receiving wastes before October 9, 1991 are not required to comply with the permeability requirement, but they are still required to be covered by two (2) feet of compacted soil and six (6) inches of topsoil.

The owner/operator must demonstrate that the cover material available for final cover (whether from on-site sources or imported from off-site areas) can meet the permeability specifications in the closure plan.

Determination of Facility's Final Cover Specification:

Determine the permeability of the underlying soils or bedrock. If the underlying soils or bedrock formation is saturated at depth, permeability can be measured by conducting tests on the water bearing zone (e.g. pump tests or slug tests). If the aquifer material is not representative of the soils or bedrock at the base of the disposal area or trench, collect undisturbed field sample for laboratory analysis (constant head or falling head permeability test).

A sufficient number of sampling points should be analyzed to fully evaluate subsurface variations in soil and bedrock types and in the associated permeabilities

Determine the permeability of final cover material. If the final cover has already been placed, collect undisturbed field sample for laboratory analysis (constant head or falling head permeability test). If the final cover has not been placed, collect a disturbed sample and perform laboratory analysis (constant head or falling head permeability test) on samples remolded in the lab at various densities to determine at what density the soil must be compacted to achieve the required permeability specification.

Determination of Permeability of Compacted Final Cover:

If the final cover has already been placed, collect an undisturbed field sample for laboratory analysis (constant head or falling head permeability test).

If the preliminary laboratory analysis has been completed on the final cover material to determine the in-place density required to achieve the required permeability specification, monitor the compaction of the final cover in the field during construction using either a nuclear moisture-density gauge or the sand-cone method.

Documentation:

Any testing data which are collected for the purpose of determining the facility's final cover specification and for the purpose of demonstrating that the final cover specifications have been met, must be maintained in the facility's operating record through the active life of the site and to the end of the post-closure period.

Engineered Containment Systems:

In order for a cap to match the bottom liner permeability, it will generally be necessary for the cap to also be an engineered containment system. See Section 5, Part D for more information about engineered containment systems.

Water Balance Covers:

The DEQ may approve an alternative final cover system design that achieves an equivalent reduction in infiltration as the standards traditional caps described above. Traditional final cover systems rely on low-conductivity (permeability) materials and resistive barrier layers (clays and geomembranes). Cover systems that rely on a combination of temporary storage of precipitation in soil near the surface and removal of stored water by evaporation and transpiration have been utilized, especially in drier climates. These cover systems may be referred to as water balance covers, alternative

covers, evapotranspirative covers, and store-and-release covers. Under the right conditions, water balance covers may perform adequately and may have lower construction costs than traditional caps. Ultimately, many factors must be considered in the selection of an appropriate final cover system including, but not limited to performance, site-specific information like the availability of suitable soils and climate, and cost. For example, a water balance cover may not be appropriate if there is not enough suitable soil onsite or if an engineered containment system is needed to address groundwater contamination.

PART C. TOPSOIL LAYER/SEEDING SPECIFICATIONS

The topsoil layer of the final cover system is used to minimize erosion of the final cover and contains a minimum of six (6) inches of earthen material that is capable of sustaining native plant growth.

Any portion of the site that has been disturbed by solid waste disposal activities shall be reseeded to minimize wind and water erosion of the final cover, consistent with the post-closure land use. Erosion of the final cover may lead to exposure of the lateral drainage layer, initiate or contribute to sliding failures or expose the waste.

Vegetative cover serves the following functions:

- evapotranspiration (the loss of water from the soil both by evaporation and by transpiration from the vegetation)
- improves the appearance of the site
- protects the final cover against wind and water erosion

Vegetation shall:

- be a diverse mix selected to be compatible with the climatic conditions
- be resistant to drought and temperature extremes
- require little maintenance
- provide sufficient plant density to minimize cover soil erosion
- have root depths that will not exceed the depth of the final cover

The use of deep-rooted vegetation, including shrubs and trees, is inappropriate because the root systems may penetrate the final cover and create pathways of percolation.

Before planting, it is important to determine the suitability of the soil for growing vegetation. This can be accomplished by analyzing a sample of the topsoil for:

- pH
- phosphorus
- potassium
- nitrogen
- specific conductance (salts)
- organic matter

The three major nutrients necessary to grow vegetation are nitrogen, phosphorus and potassium (N, P, K). The amount to be added to the soil depends on the results of the soil tests and the crop need.

To determine the application rate of a specific nutrient, the following formula is used:

$$\text{Lbs/Acre of nutrient to apply} = \frac{\text{Crop Need}}{\% \text{ nutrient in fertilizer}}$$

Example 1:

Calculate the amount of fertilizer required for a grass crop needing 80 lbs/acre of nitrogen. The fertilizer contains 20% nitrogen.

Solution:

$$\frac{80}{0.20} = \underline{400 \text{ lbs/acre of fertilizer}}$$

Crop need is determined by subtracting the quantity available in the soil from the quantity needed to grow the crop.

Planting and protecting the seed is accomplished as follows:

- drill or disc seed into soil to reduce wind and water damage;
- plant along the contour to reduce erosion rills;
- use enough seed; and
- apply a mulch.

Mulch consists of straw or grass hay that is free of noxious weeds. To avoid temporary nitrogen deficiency, apply 10 pounds of nitrogen per 1,000 pounds of straw or grass hay mulch material.

The mulch:

- protects the slopes from erosion
- holds soil and seed in place
- provides water holding capacity
- protects against weed growth
- proceeds immediately after seeding
- should be anchored by discing into soil

Timing of seeding (spring or fall) is critical to successful germination and establishment of the vegetative cover. When to seed is dependent upon the climatic conditions for the area of the landfill.

Contact the local Natural Resources Conservation Service, Bureau of Land Management, or Wyoming Department of Transportation office for specifications for establishing vegetative cover in areas similar to where the landfill is located.

Alternate designs in lieu of 6" of topsoil to address vegetative problems in areas that are not capable of sustaining plant growth may be approved by the DEQ.

One example of an alternate design is an armored surface. An armored surface consists of gravel or crushed rock. Armored surfaces are:

- capable of protecting the underlying layer during extreme weather events of wind and/or rainfall
- capable of accommodating settlement of the underlying material
- designed with at least a 2% slope
- capable of controlling the rate of soil erosion

SECTION 8
LANDFILL POST-CLOSURE

SECTION 8

LANDFILL POST-CLOSURE

TRAINING OBJECTIVES:

- 1) To provide landfill managers with a clear understanding of the regulatory post-closure standards that must be met for monitoring and inspections, record keeping and post-closure certification.
- 2) To explain the rationale and intent of the regulatory standards.
- 3) To familiarize landfill managers with methods and suggestions for complying with the regulatory standards.

PART A. GENERAL

Post-closure period:

The post-closure period for MSWLFs that continued to receive wastes on or after October 9, 1997 shall extend for a period of not less than thirty (30) years after certification of all facility closure activities is approved by the DEQ. The minimum post-closure period may be terminated by the DEQ at an earlier date if the DEQ determines that the facility has been adequately stabilized and that the environmental monitoring or control systems have demonstrated that the facility closure is protective of public health and the environment consistent with the purposes of the act.

The post-closure period for municipal solid waste landfills that ceased receipt of waste prior to October 9, 1997 shall extend for the period specified in rules in place May 28, 2013 and any closure permit issued for the facility.

Post-closure Period Extension:

Following the initial minimum post-closure period, the post-closure period shall be automatically extended until such time when the DEQ determines, upon petition by the operator accompanied by submission of relevant information, that the facility has been adequately stabilized in a manner protective of human health and the environment.

Petitions to Terminate Post-Closure Care:

Petitions to terminate the post-closure period shall include certification from a Wyoming registered professional engineer that post-closure care has been completed in compliance with the post-closure plan and in a manner protective of human health and the environment.

PART B. MONITORING AND INSPECTIONS

Post-closure care requirements focus on the operation and maintenance of four (4) systems that prevent or monitor releases from the closed landfill:

1. Cover system
 - maintain the integrity and effectiveness of any final cover
 - correct the effects of settlement, subsidence, erosion, or other events
2. Leachate collection system
 - maintain and operate the leachate collection system, if applicable
3. Ground water monitoring system
 - maintain the integrity and effectiveness of any final cover
 - correct the effects of settlement, subsidence, erosion, or other events
4. Gas monitoring and collection system
 - monitor the gas
 - maintain and operate the gas monitoring and collection system

Activities and frequency of inspections are subject to review by the DEQ to ensure that units are monitored and maintained for as long as is necessary to protect human health and the environment.

Inspections should be conducted and documented as required by the facility's approved closure permit and should include the following:

- condition of final cover (e.g. animal burrows, cracks)
- determination if settlement has occurred
 - periodic surveying of the final cover system can be used to demonstrate that the subsurface of the landfill has stabilized

- depressions caused by settlement may lead to ponding and should be filled with soil and revegetated
 - excessive settlement may warrant reconstructing the final cover
 - damage caused by settlement such as tension cracks and tears in synthetic membranes should be repaired
- determination if erosion has occurred
 - large and small crevices may form where water has eroded the cover
 - may lead to exposure of the synthetic membrane or waste
 - may lead to increased infiltration of surface water into the landfill
 - erosion of run-on/run-off structures should be repaired to ensure the operation of the structure stays at the design level
 - areas showing signs of erosion should be repaired immediately
- condition of vegetative cover
 - may require mowing to aid in suppression of weed growth and increase vigor of certain grass species
 - fertilizer schedules may be necessary for certain cover types
- condition of leachate collection and removal pipes
- condition of gas monitoring systems and monitoring wells
 - may require mowing to aid in suppression of weed growth and increase vigor of certain grass species
- condition of surface water control structures

PART C. RECORD KEEPING

Records of all post-closure inspection activities should be kept in a log book so that changes in any aspect of the closed landfill can be monitored.

In addition to the record keeping required throughout the active life of the landfill, records of the following post-closure activities must be maintained throughout the post-closure period:

- ground water monitoring data, including any additional monitoring or corrective action that may have been necessary
- methane monitoring data, including any additional monitoring or corrective action that may have been necessary
- inspection reports, including any problems which required maintenance or repair and a detailed discussion on the remedies for these problems
- settlement measurements

Records should also be kept of changes in post-closure care personnel to ensure that changing personnel will not affect the post-closure care due to lack of knowledge of post-closure care activities.

PART D. POST-CLOSURE CERTIFICATION

The post-closure period is at least 30 years, although owners can petition the DEQ to terminate the post-closure period earlier if they can demonstrate that the landfill has been stabilized.

In all cases, the minimum post-closure period is automatically extended until such time that the operator provides a successful petition to terminate the post-closure period.

The petition to terminate the post-closure period shall include a certification from a Wyoming registered professional engineer that post-closure care has been completed in compliance with the post-closure plan and in a manner protective of human health and the environment.

At a minimum, the engineer's post-closure certification should include the following documentation:

- **Ground Water Monitoring Data**

Provide a detailed analysis of all available ground water monitoring data collected during the active life, closure process and post-closure period. The analysis should also include a graphical trend analysis and may include a statistical analysis.

- **Methane Monitoring Data**

Provide a detailed analysis of all available methane monitoring data. The analysis should include a graphical trend analysis of at least 12 consecutive months of recent methane monitoring data. Historical data, if available, should also be evaluated to determine if methane levels are increasing or decreasing with time.

- **Post-Closure Inspection Reports**

Provide copies of all post-closure inspection reports to demonstrate that the site has been inspected on a regular basis to evaluate the integrity and stability of the final cover and surface water diversion structures. If post-closure inspections of the facility identified problems that required maintenance or repair, these problems and associated remedies should be discussed in detail.

- **Periodic Settlement Measurements**

Provide a demonstration that settlement has not created irregularities in the final cover surface which allow infiltration, ponding or increase the potential for erosion. A demonstration that additional settlement will not occur or that it will not be significant enough to create problems should also be included.

- Final Disposition of Environmental Monitoring System

If the operator wishes to plug and abandon any methane or ground water monitoring wells, a written request must be submitted and approved by the DEQ before plugging and abandonment occurs. Plugging and abandonment of the monitoring wells must be completed in compliance with the provisions of DEQ Water Quality Rules and Regulations. If the monitoring wells are not going to be plugged and abandoned, the operator should provide a justification and a discussion of the planned use of the monitoring wells.

- Post-Closure Certification

Provide a post-closure certification statement that is signed, dated and stamped by a Wyoming registered professional engineer.

NOTE: Closure and post-closure requirements are intended to prevent future releases from closed landfills. In the event that a future release does occur, certified compliance with the closure and post-closure requirements does not relieve the owners and operators from the duty to take corrective action as necessary to protect human health and the environment. Landfill owners should maintain a minimal inspection and monitoring program once the facility has complied with the state's closure and post-closure regulatory program.

SECTION 9
FINANCIAL ASSURANCE

SECTION 9

FINANCIAL ASSURANCE

TRAINING OBJECTIVES:

- 1) To familiarize landfill managers with the general regulatory requirements for financial assurance.
- 2) To provide landfill managers with an understanding of the state trust pool account option and to explain how contributions to the state trust pool account are calculated.
- 4) To discuss the various methods available for estimating closure and post-closure costs, their limitations and appropriate uses.

PART A. GENERAL REQUIREMENTS

Financial assurance means that solid waste management facilities must show evidence that there are adequate sources of funds available (assure that there are finances) to cover closure, post-closure and remediation costs should the owner/operator fail to meet their responsibilities.

Financial Assurance Provides a Guarantee that Funds Will Be Available for:

- closure
- post-closure care
- corrective action

Why is Financial Assurance Necessary?

- to prevent closure, post-closure and clean-up costs from becoming a tax-payer burden in the event of landfill abandonment or operator non-compliance
- it is required by both state and federal regulations

Financial Assurance Mechanisms Can Include:

- cash
- a federally insured certificate of deposit (Bank CD)
- government-backed securities such as savings bonds, or collateral mortgage obligation (CMO) bonds issued by Fannie Mae or Freddie Mac, and other securities which are supported by the full faith and credit of the U.S. government
- a letter of credit from an approved issuing bank that is irrevocable (cannot be revoked) during the annual bonding period
- a self bond - a bond provided by the operator based upon the financial solvency of the operator, parent corporation, or federal agency (bond cannot exceed 25% of net worth)
- a surety bond - a bond issued by a surety company guaranteeing payment or performance
- state guarantee trust account (see Part B)

PART B. STATE GUARANTEE TRUST ACCOUNT

The State Guarantee Trust Account is a financial instrument set up by the State of Wyoming, through W.S 35-11-515, to guarantee that adequate monies will be available for closure and post-closure of municipal landfills. Municipal landfills are not required to participate in the account, but it is simply a convenient option available to them to meet the federal and state financial assurance requirements.

Each participating facility shall pay annually into the account a premium, the sum of which at facility closure will equal no less than 3% of the sum of the closure and post-closure cost estimates.

Participation in the State Fund Account:

- is available to municipally owned or operated MSW landfills
- involves annual premiums based upon closure and post-closure cost estimates
- provides funds to complete closure or post-closure obligations, if the facility owner fails to meet those obligations

To Participate in the Account, the Landfill Owner Must:

- notify DEQ of the intent to participate in the program
- submit completed worksheets (provided by the DEQ) showing calculated closure and post-closure costs
- submit the annual premium payment

Refunds Can Be Obtained from the Account:

- for 90% of the amount paid into the account for closure costs, once a registered professional engineer has certified closure, and DEQ approval is received
- for 90% of the amount paid into the account for post-closure costs, once a registered professional engineer has certified proper completion of the post-closure period, and DEQ approval is received
- for 90% of the total amount paid into the account, if the facility elects to withdraw from participation and use an alternate financial assurance mechanism
- the refund amount may be reduced by any unrecovered expenditures

Closure and Post-closure Costs Can Be Calculated by the Following Methods:

- completing worksheets with cost estimates provided by DEQ
- obtaining site-specific written bids
- using closure and post-closure cost estimates prepared as part of the closure plan

Calculating the Annual Premium Payment:

1. Calculate the remaining usable disposal capacity of the facility, expressed as years, using information from the facility permit application.
2. Calculate the annual amount to be paid to the account using the following procedure:

Calculate three percent (3%) of the sum of closure and post-closure costs using the following formula:

3% of the sum of closure and post-closure costs = $(0.03 \times (\text{Closure cost} - \text{the amount of net assets earmarked for closure costs})) + (0.03 \times (\text{Post-closure cost} - \text{the amount of net assets earmarked post-closure costs}))$

3. The operator shall account for closure and post-closure liabilities and costs in accordance with Generally Accepted Accounting Principles and certify to the earmarking of the accumulated net assets, subject to audit.
4. Calculate the balance due to the account by deducting the total of previous payments to the account from 3% of the sum of closure and post-closure costs.

Balance due = 3% of the sum of closure and post-closure costs – the total of previous payments to the account

5. Calculate annual payments to the account by dividing the balance due by the years of remaining disposal capacity.

Annual payment = Balance due / years of remaining disposal capacity

You Still Need to Budget for Closure and Post-closure Costs Because:

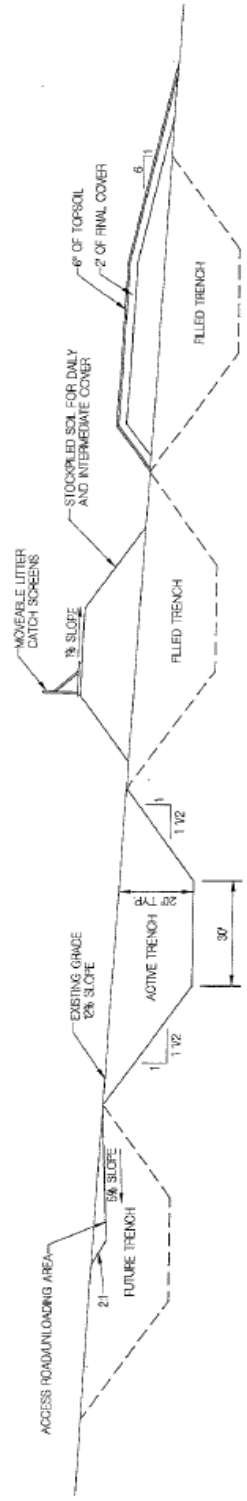
- your contribution to the state fund is only refunded after closure or post-closure is completed and so is not available for that use
- your contribution to the state fund account is only a very small percentage (3%) of your total estimated closure and post-closure costs, all of which must be budgeted
- the fund relies on the pooled contributions from many facilities in order to cover costs at a facility that has defaulted
- **DEQ worksheets may not represent actual costs for an individual facility - they contain many assumptions and should not be used in budget calculations**

APPENDICES

APPENDIX

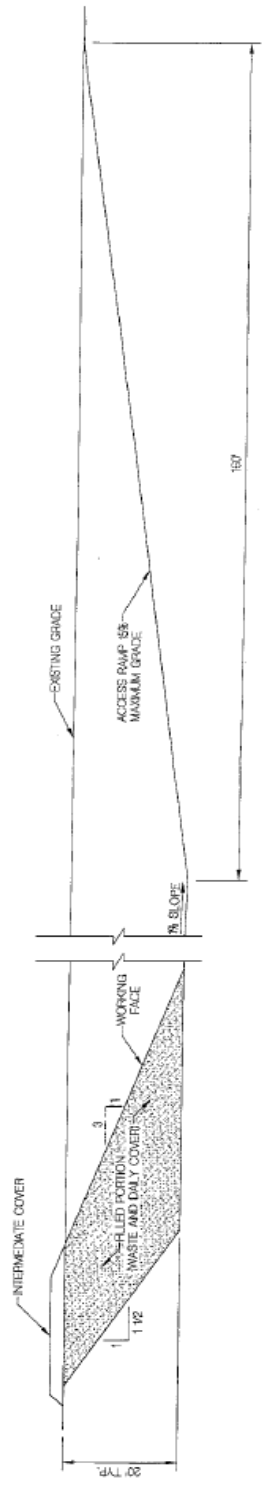
- A EXAMPLE PLANDRAWINGS**
- B MATHEMATICS FOR LANDFILL OPERATIONS**
- C FIELD MEASUREMENTS FOR LANDFILL OPERATIONS**
- D SAMPLE WRITTEN EXAMINATION QUESTIONS--OPERATOR'S MODULE**
- E SAMPLE WRITTEN EXAMINATION QUESTIONS--MANAGER'S MODULE**

APPENDIX A
EXAMPLE PLAN DRAWINGS



TYPICAL TRENCH EXCAVATION CROSS SECTION

SCALE: 1" = 30'



TYPICAL TRENCH EXCAVATION LONGITUDINAL SECTION

SCALE: 1" = 20'

DATE	2/21/01	BY	W. J. BROWN	CHKD BY	J. A. BROWN	DESIGNED BY	J. A. BROWN	PROJECT NO.	100-1000000000	PROJECT NAME	LANDFILL SECTIONS	SHEET NO.	4	TOTAL SHEETS	4
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APPENDIX B

MATHEMATICS FOR LANDFILL OPERATIONS

APPENDIX B

MATHEMATICS FOR LANDFILL OPERATIONS

This section presents the basic mathematics required by landfill operators and managers for the operation of a landfill. A general understanding of the mathematics will help ensure the facility is operated according to the approved operating plan.

Topics in this section include:

- Common Shapes of Landfill Areas
- Calculating Areas
- Calculating Volumes
- Conversions Between Volumes and Weights
- Reading and Understanding Slopes

Common Shapes of Landfill Areas

1. Square: four equal sides and four right (90°)

angles Examples:

- Landfill boundary
- Special waste area

2. Rectangle: four sides, opposite sides are equal and four right (90°)

angles Examples:

- Landfill boundary
- Special waste area
- Trench or area fill area

3. Trapezoid: four sides, two parallel

sides Examples:

- Trench cross-section
- Ditch cross-section

Calculating Areas

1. Square

$$\text{Area (A) of a square} = L \times W$$

Where, L = Length, measured in feet
W = Width, measured in feet

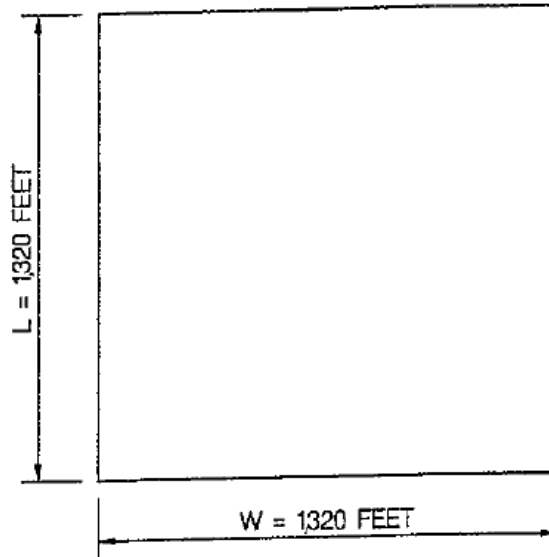


Figure B-1
Square

Example 1 (see Figure B-1):

$$L = 1,320 \text{ feet}$$

$$W = 1,320 \text{ feet}$$

$$\begin{aligned} A &= L \times W \\ &= 1,320 \text{ feet} \times 1,320 \text{ feet} \\ &= 1,742,400 \text{ square feet} \\ &= 1,742,400 \text{ ft}^2 \end{aligned}$$

2. Rectangle

$$\text{Area (A) of a rectangle} = L \times W$$

Where, L= Length, measured in feet
 W= Width, measured in feet

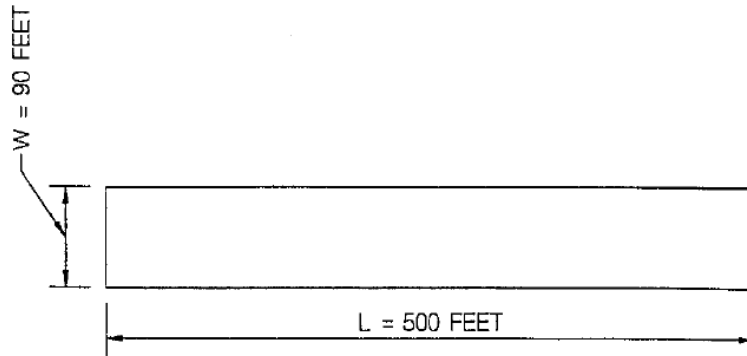


Figure B-2
Rectangle

Example 2 (see Figure B-2):

$$L = 500 \text{ feet}$$

$$W = 90 \text{ feet}$$

$$\begin{aligned} A &= L \times W \\ &= 500 \text{ feet} \times 90 \text{ feet} \\ &= 45,000 \text{ square feet} \\ &= 45,000 \text{ ft}^2 \end{aligned}$$

3. Trapezoid

$$\text{Area (A) of a trapezoid} = W_A \times H$$

Where, W_A = Average width, measured in feet
= $\frac{(\text{Width at top} + \text{Width at bottom})}{2}$
= $\frac{(W_t + W_b)}{2}$
 H = Height, measured in feet

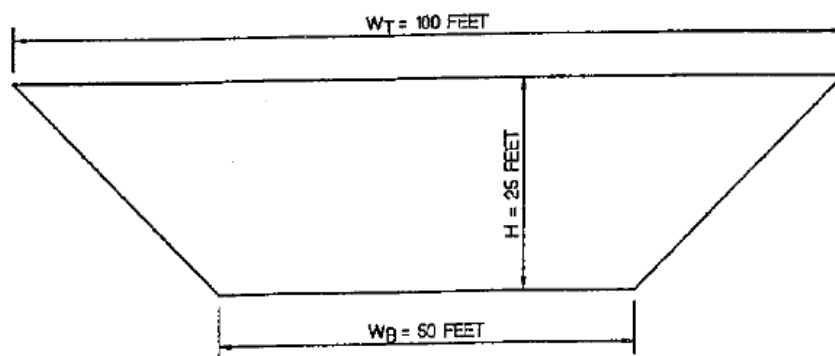


Figure B-3
Trapezoid

Example 3 (see Figure B-3):

$$W_T = 100 \text{ feet}$$

$$W_B = 50 \text{ feet}$$

$$H = 25 \text{ feet}$$

$$W_A = \frac{(100 \text{ feet} + 50 \text{ feet})}{2} = 75 \text{ feet}$$

$$\begin{aligned} A &= W_A \times H \\ &= 75 \text{ feet} \times 25 \text{ feet} \\ &= 1,875 \text{ square feet} \\ &= 1.875 \text{ ft}^2 \end{aligned}$$

4. Units For Area Calculations:

Area calculations are typically measured in units of Acres. The conversion from square feet to acres consists of:

$$\text{Acres} = [\text{_____}] \text{ft}^2 \times \frac{\text{Acre}}{43,560 \text{ ft}^2} = [\text{_____}] \text{ft}^2 \div 43,560$$

Example 4:

Calculate the number of acres in Example 1 and Example 2:

$$\text{Example 1: Acres} = 1,742,400 \text{ ft}^2 \div 43,560 = 40 \text{ Acres}$$

$$\text{Example 2: Acres} = 45,000 \text{ ft}^2 \div 43,560 = 1.03 \text{ Acres}$$

Calculating Volumes

Volume calculations are important in the daily operations of landfills. They are used to determine the amount of excavation required for new trenches and to determine the rate at which landfill space is being used up.

1. Square Area

$$\text{Volume (V) of a square area} = A \times H$$

Where, A = Area of square area, measured in square feet
 = Length x Width
 H = Height, measured in feet

Example 5:

Calculate the volume of the square area in Example 1 if the cut is 10 feet

$$\begin{aligned} A &= 1,742,400 \text{ square feet} \\ H &= 10 \text{ feet} \quad A \times H \\ A \times H &= 1,742,400 \text{ square feet} \times 10 \text{ feet} \\ v &= 17,424,000 \text{ cubic feet} \\ &= \underline{17,424,000 \text{ ft}^3} \end{aligned}$$

2. Rectangular Area

$$\text{Volume (V) of a rectangular area} = A \times H$$

Where, A = Area of rectangular area, measured in square feet
 = Length x Width
 H = Height, measured in feet

Example 6:

Calculate the volume of the rectangular area in Example 2 if the cut is 15 feet:

$$A = 45,000 \text{ square feet}$$

$$H = 15 \text{ feet}$$

$$\begin{aligned} V &= A \times H \\ &= 45,000 \text{ square feet} \times 15 \text{ feet} \\ &= 675,000 \text{ cubic feet} \\ &= 675,000 \text{ ft}^3 \end{aligned}$$

3. Trapezoidal Area

$$\text{Volume (V) of a trapezoidal area} = WA \times H \times LA$$

Where, WA = Average width, measured in feet
 = $\frac{(\text{Width at top} + \text{Width at bottom})}{2}$
 = $\frac{(W_T + W_B)}{2}$
 H = Height, measured in feet
 LA = Average length, measured in feet
 = $\frac{(\text{Length at top} + \text{Length at bottom})}{2}$
 = $\frac{(L_T + L_B)}{2}$

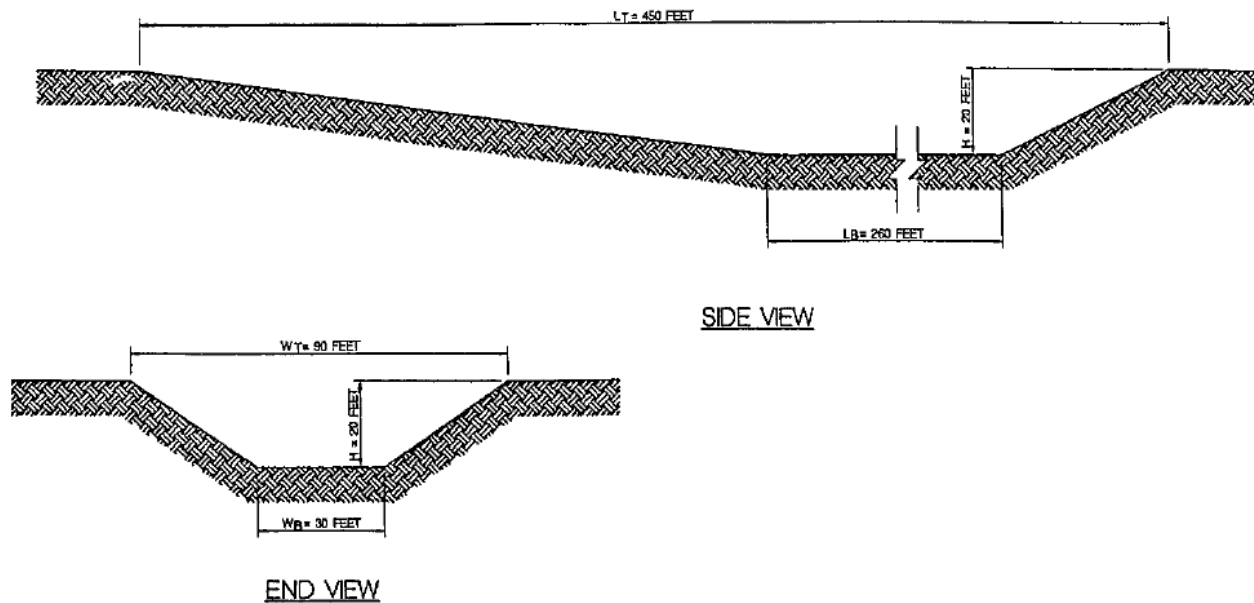


Figure B-4
Trench

Example 7

Calculate the volume of a trench with the sections shown in Figure B-4:

$$W_T = 90 \text{ feet}$$

$$W_B = 30 \text{ feet}$$

$$H = 20 \text{ feet}$$

$$L_T = 450 \text{ feet}$$

$$L_B = 260 \text{ feet}$$

$$W_A = \frac{(90 \text{ feet} + 30 \text{ feet})}{2} = 60 \text{ feet}$$

$$L_A = \frac{(450 \text{ feet} + 260 \text{ feet})}{2} = 355 \text{ feet}$$

$$\begin{aligned} V &= W_A \times H \times L_A \\ &= 60 \text{ feet} \times 20 \text{ feet} \times 355 \text{ feet} \\ &= 426,000 \text{ cubic feet} \\ &= \underline{426,000 \text{ ft}^3} \end{aligned}$$

4. Units For Volume Calculations:

Volume calculations are typically measured in units of Cubic Yards (yd³) The conversion from cubic feet to cubic yards consists of:

$$\text{Cubic Yards} = [\text{ }] \text{ ft}^3 \times \frac{\text{Cubic Yard}}{27 \text{ ft}^3} = [\text{ }] \text{ ft}^3 \div 27$$

Example 8:

Calculate the number of cubic yards in Example 7:

$$\text{Cubic yards} = 426,000 \text{ ft}^3 \div 27 = 15,778 \text{ yd}^3$$

Volumes are sometimes shown in "acre feet". One acre foot is described as the volume that would cover one acre to a depth of one foot. The formula for acre feet is as follows:

$$\text{Acre feet} = [\text{ }] \text{ Acres} \times \text{Average depth}$$

Example 9:

Calculate the number of acre feet of a 1.03 acre area with an average depth of 2 ½ feet:

$$\text{Acre feet} = 1.03 \text{ Acres} \times 2.5 \text{ feet} = 2.58 \text{ Acre feet}$$

Conversions Between Volumes and Weights

Converting between volumes and weights can be accomplished by multiplying a known volume of material by the density of the material. Density is defined as the mass of the material per unit volume and is normally expressed in terms of lbs/ft³ or lbs/yd³.

For municipal solid waste, the "in-place" density (after being compacted by the landfill equipment) ranges from 800 lbs/yd³ to 1,200 lbs/yd³. An average of 1,000 lbs/yd³ is typically used.

The conversion from cubic yards of a material to tons of a material is as follows:

$$\text{Tons of Material} = [\text{_____}] \text{ yd}^3 \times \frac{[\text{_____}] \text{ lbs}}{\text{yd}^3} \times \frac{\text{Ton}}{2,000 \text{ lbs}}$$

Example 10:

Calculate the number of tons of 300 yd³ of municipal solid waste using an average density of 1,000 lbs/yd³:

$$\text{Tons of solid waste} = \frac{300 \text{ yd}^3 \times 1,000 \text{ lbs}}{\text{yd}^3} \times \frac{\text{Tons}}{2,000 \text{ lbs}} = 150 \text{ tons}$$

Reading and Understanding Slopes

Slope is used to express the steepness of a grade and are expressed as either a percentage (e.g. 25%) or as a ratio (e.g. 4:1).

Slope expressed as a percentage is calculated by the following formula:

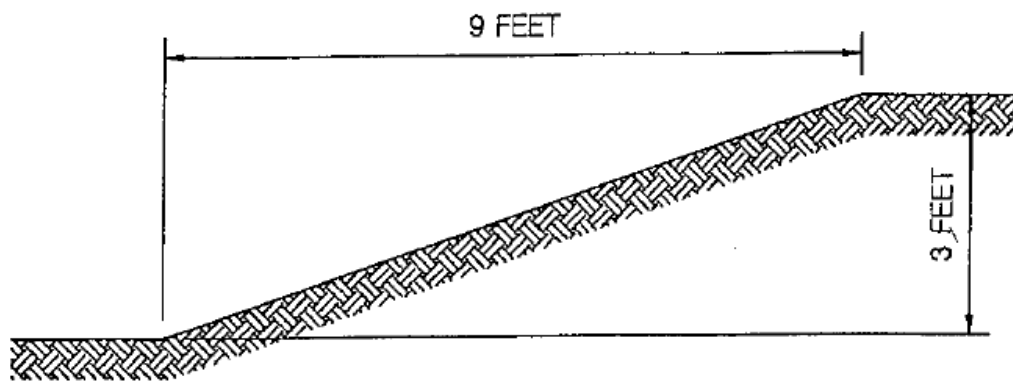
$$\% \text{ Slope} = \frac{\text{Vertical Distance}}{\text{Horizontal Distance}} \times 100$$

When expressed as a ratio, the first number indicates the horizontal distance and the second number indicates the difference in vertical height that occurs for that horizontal distance.

The ratio can be calculated using the following formula:

$$\text{Horizontal Distance} : 1 = \frac{100}{\% \text{ Slope}}$$

Example 11:



Slope expressed as a percentage = $\frac{3 \text{ feet}}{9 \text{ feet}} \times 100 = \underline{33\%}$

Slope expressed as a ratio = $\frac{100}{33} = \underline{3:1}$

APPENDIX C

FIELD MEASUREMENTS FOR LANDFILL OPERATIONS

APPENDIX C

FIELD MEASUREMENTS FOR LANDFILL OPERATIONS

This section presents some basic techniques for obtaining measurements in the field to ensure the operation of the landfill complies with the approved operating plan. Field measurements include distance, elevation and slope.

The tasks discussed in this section include:

- Measuring Distance
- Measuring Elevation
- Measuring Slope

Measuring Distance

Distance is the true horizontal measurement of the length between two points. Once you have determined the distance between the points on the plan drawing by measuring with a ruler or engineering scale, it can be measured in the field. Measurements in the field can be made using either expedient means or using a measuring tape, wheel or other distance measuring instruments.

Expedient measurements consist of pacing and can be made where an approximate distance is satisfactory. More accurate measurements are made using a tape, wheel or other distance measuring instrument, such as a transit and a level rod.

When using a tape, it is important to keep the tape horizontal. For moderate precision on level, smooth ground, the tape can be placed directly on the ground. Where the ground is level but uneven, both ends of the tape should be held equal distance above the ground. For accurate measurement on sloping ground, hold one end of the tape on the ground at the high point and raise the low end of the tape until it is level.

Measuring Elevation

Elevation is the vertical distance between points. Plan elevations are drawn based on sea level data or using an assumed elevation based on a fixed point on the site. The most accurate method of determining elevation is with a transit or builder's level and a level rod.

The terms used in determining elevation include:

- Benchmark (BM) - a permanent, immovable object that has a known elevation. Benchmarks are either referenced to mean sea level or given an assumed elevation.

- Height of Instrument (HI) - the elevation of the center horizontal cross hair on the *level* instrument.
- Backsite (BS) - the rod reading when sighted through the *level* or transit to a level rod placed on the benchmark or on a point of known elevation.
- Foresite (FS) - the rod reading when sighted through the level or transit to a level rod placed on the point where the *elevation* is being determined.

1. Reading a Level Rod

Level rods are divided into tenths and hundreds of feet instead of inches. Figure C-1 shows the correct interpretation when reading a rod if the horizontal cross hair falls on the point indicated.

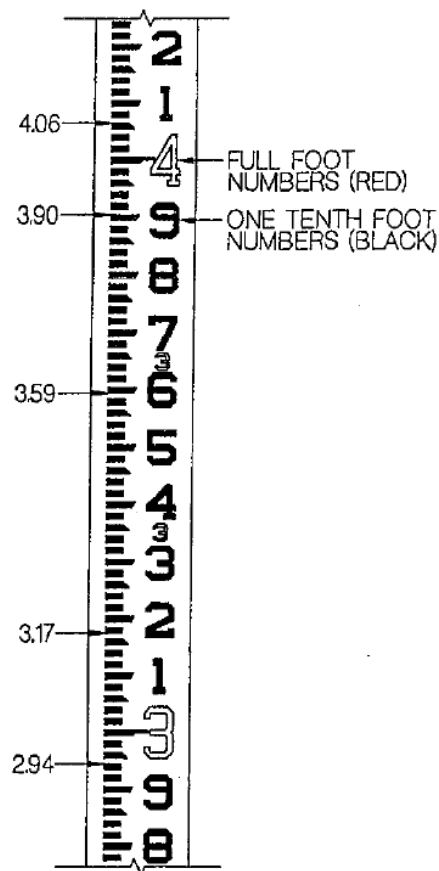


Figure C-1
Reading a Level Rod

2. Steps To Determine Elevation - One Instrument Setup (see Figure C-2)

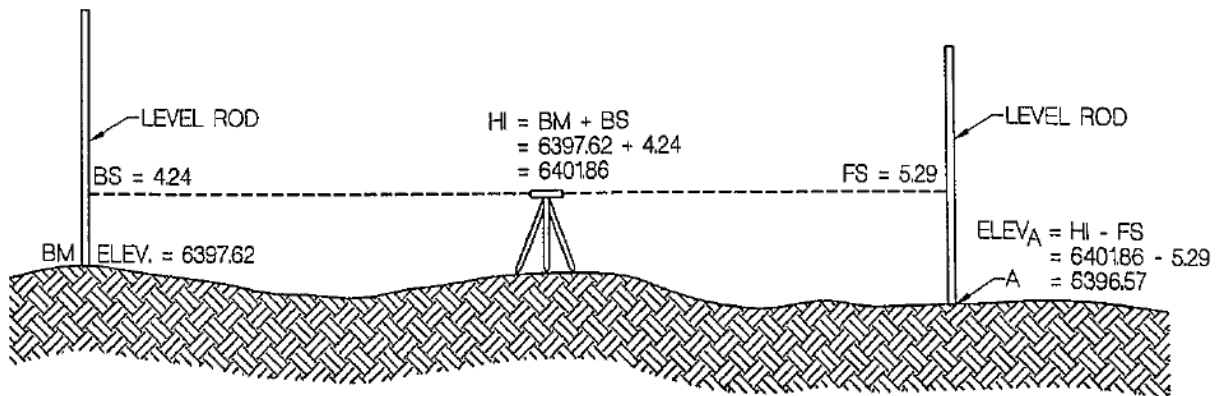


Figure C-2
Determining Elevation - One Instrument Setup

Step 1: Set the instrument up and level the instrument in the line of sight with the benchmark (BM) making sure that the rod can be seen through the instrument.

Step 2: Have the rod holder place the rod on the benchmark making sure that the rod is straight. If the rod reading is greater than 3 feet, it is usually necessary to wave the rod by moving it slowly in the direction of the instrument about 10° and back past plumb by the same amount. The instrument man then takes the lowest reading.

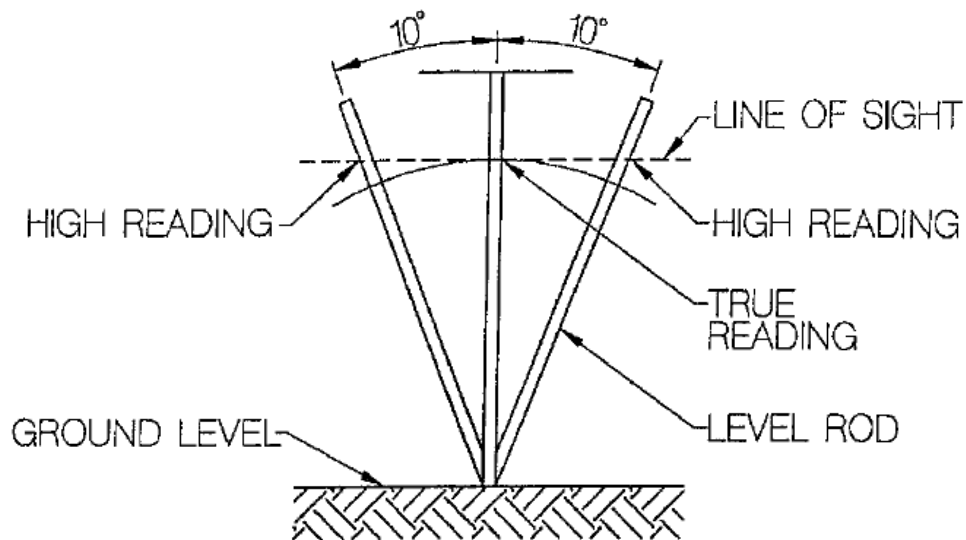


Figure C-3
Holding a Level Rod

Step 3: Determine the backsite (BS) rod reading and calculate the height of instrument: **HI = BM + BS**

Step 4: Move the level rod to the point where the elevation is to be determined and obtain the foresite (FS) rod reading.

Step 5: Calculate the elevation at the desired point: **Elevation = HI – FS**

Due to the nature of landfills, more than one instrument setting may be required to obtain the necessary elevations.

3. Steps To Determine Elevation - Multiple Instrument Setups (see Figure C-4)

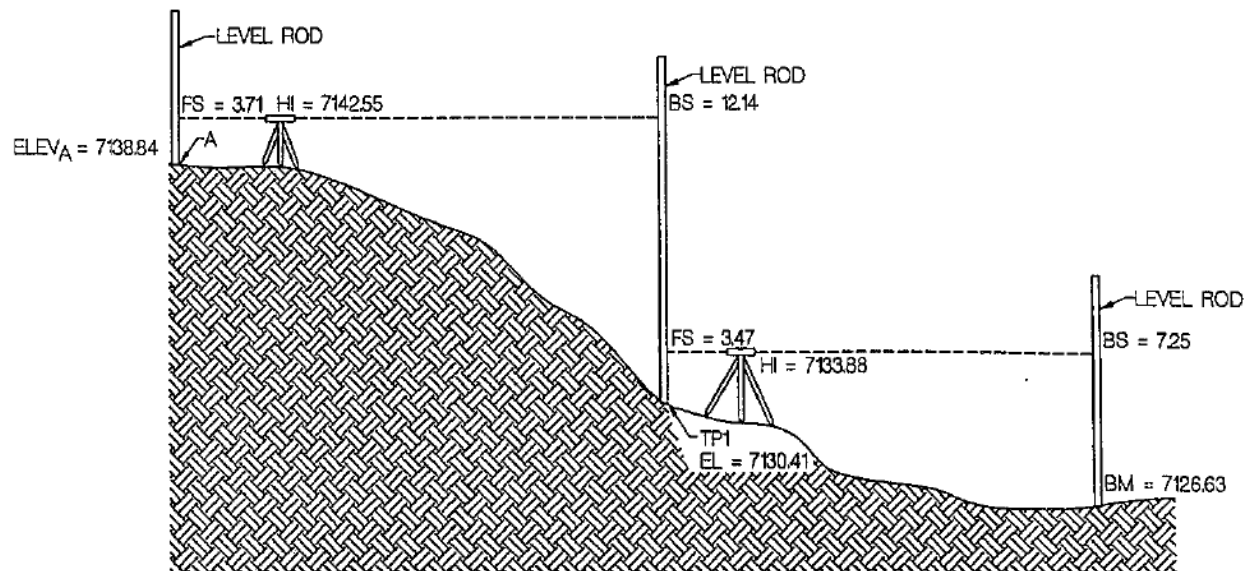


Figure C-4
Determining Elevation - Multiple Instrument Setups

- Step 1: Using the method described previously (steps 1 through 5), establish the elevation of a turning point (TP).
- Step 2: Leave the rod holder at the TP and relocate the instrument in line of sight with the TP. Determine the BS rod reading and calculate the HI.
- Step 3: Move the level rod to the point where the elevation is to be determined and obtain the foresite (FS) rod reading.
- Step 4: Calculate the elevation at the desired point.

If necessary, repeat steps until the elevation of the desired point is obtained.

Figure C-5 shows the correct procedure for recording the survey data in Figure C-4.

Miscellaneous Elevations					Example Landfill		JAL T, N LMW R		January 31, 1997 Overcast, Breezy, 45°F			②
POINT	BS (+)	HI	FS (-)	ELEV								
BM	7.25	7133.88		7126.63					Top of survey cap, NE of landfill			
TP1	12.14	7142.55	3.47	7130.41								
A			3.71	7133.84					2"x2" hub at top of hill			

Figure C-5
Recording Survey Data

Measuring Slope

1. Measuring Slope Using a Transitor Builders Level

Step 1: Determine the difference in elevation between the top and toe of the slope or two intermediate points along the slope using the methods previously discussed.

Step 2: Determine the horizontal distance between the two points.
Do not measure the distance along the slope.

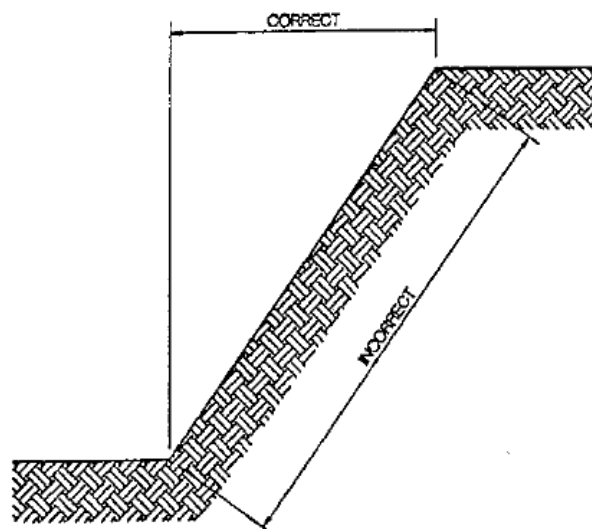


Figure C-6
Measuring Horizontal Distance

Step 3: Calculate the percent of slope using the method discussed in Appendix B.

2. Measuring Slope Using a Hand Level

An acceptable alternative to using a transit or builders level is to use a hand level. Hand levels are not as accurate over long distances, but are easier to use and less expensive.

Steps to using a hand level: (see Figure C-8)

Step 1: Pick a stationary object or place a grade stake in the ground up the slope.

Step 2: Go downslope until the object is at eye level.

Step 3: Site through the hand level and adjust your position on the slope until the bubble is centered on the base of the object.

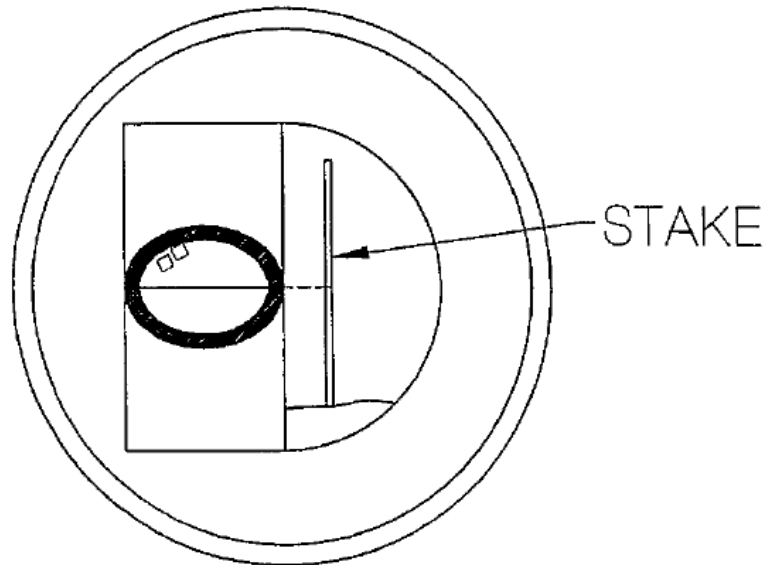


Figure C-7
View Through a Hand Level

Step 4: Measure the distance from your eyes to the ground and from your position to the object.

Step 5: Calculate the % of slope: $\% \text{ Slope} = \frac{\text{Height}}{\text{Distance}} \times 100$

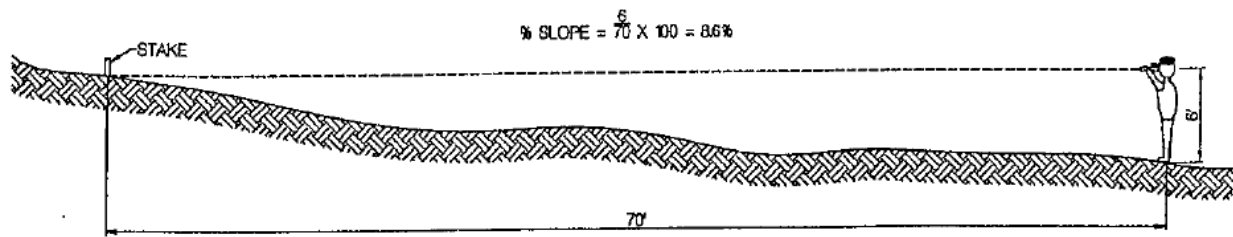


Figure C-8
Measuring Slope with a Hand Level

For measuring cut/fill slopes with a hand level, refer to Figure C-9:

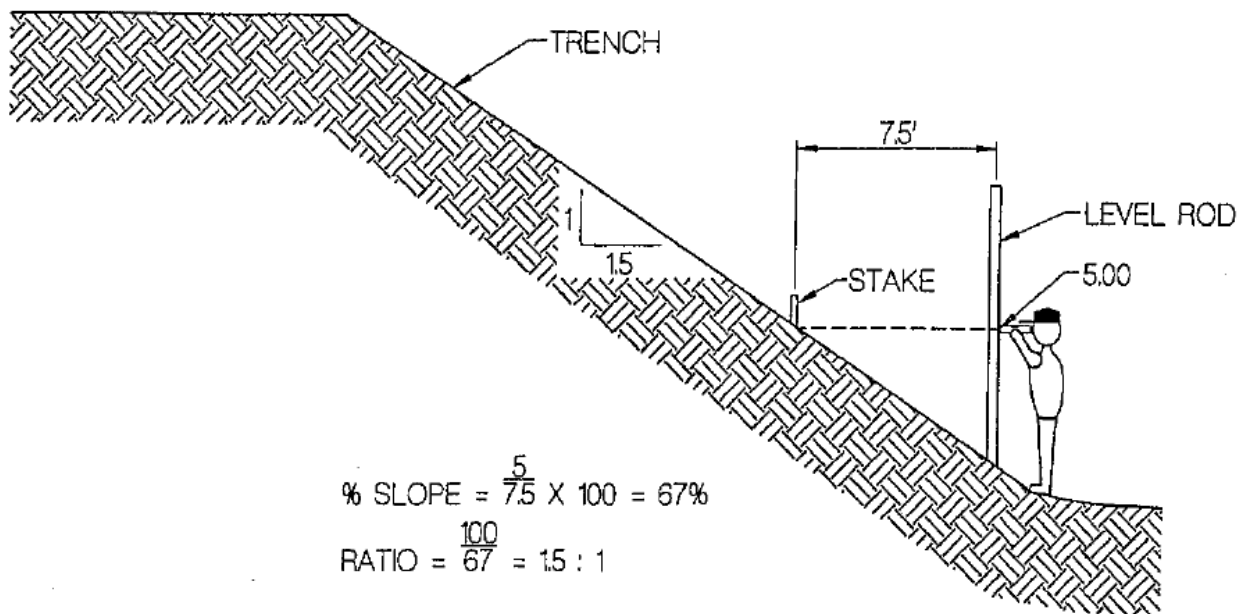


Figure C-9
Measuring Cut/Fill Slopes with a Hand Level

APPENDIX D

SAMPLE WRITTEN EXAMINATION QUESTIONS--OPERATOR'S MODULE

Sample Written Examination Questions Operator's Module

1. Is the following statement true or false?

A municipal solid waste (MSW) landfill is an engineered facility designed to provide safe, nuisance-free disposal of solid wastes.

- A. True
- B. False

2. Topsoil stockpiles can be protected from wind and water erosion by:

- A. Keeping the stockpile low
- B. Establishing vegetation
- C. Orienting the stockpile parallel to the prevailing wind direction
- D. All of the above

3. Is the following statement true or false?

Run-off structures are not needed for the closed portion of a landfill since the final cover has already been installed.

- A. True
- B. False

4. If the vertical distance between two points is six (6) feet and the horizontal distance between two points is twelve (12) feet, what is the percent slope between the two points?

- A. 2%
- B. 20%
- C. 5%
- D. 50%

5. Given a benchmark (BM) elevation of 150.0 feet, a backsight (BS) reading of 5.0 feet and foresite (FS) reading to point A of 10.0 feet, what is the elevation of point A?

- A. 145.0 feet
- B. 150.0 feet
- C. 155.0 feet
- D. 160.0 feet

6. Adequate waste compaction is best accomplished using a dozer or compactor with a weight of at least:
- A. 32,000 pounds
 - B. 45,000 pounds
 - C. 70,000 pounds
 - D. 90,000 pounds
7. No more than _____ scrap tires can be stored at a landfill at any one time.
- A. 3,000
 - B. 1,500
 - C. 5,000
 - D. 500
8. Is the following statement true or false?

Special wastes and specialty wastes refer to the same types of waste materials.

- A. True
- B. False

9. Landfill records must include logs of:

- A. Litter Collection
- B. Waste Compaction and Covering
- C. Hazardous Waste Screening
- D. All of the above

10. Is the following statement true or false?

Salvaging is prohibited because it is dangerous and can lead to injury or death.

- A. True
- B. False

11. A solid waste manager is required to be able to demonstrate a working knowledge of the facility's approved operating plan:

- A. within 3 months following assumption of duties
- B. within 6 months following assumption of duties
- C. within 30 days following assumption of duties
- D. only if the facility is out of compliance

12. Is the following statement true or false?

Wyoming now has two types of landfills; Type I and Type II.

- A. True
- B. False

13. One characteristic of the continuous trench fill method is:

- A. it increases earth moving requirements
- B. it results in the best use of air space, maximizing site capacity and life
- C. it reduces litter problems
- D. it uses more land surface per volume of waste disposed

14. Is the following statement true or false?

A continuous trench fill is a category of trench fill that utilizes progressive trench excavation to maximize "between trench" spaces.

- A. True
- B. False

15. A prepared refuse fill in which waste materials are processed, by compression, into large rectangular blocks is called a fill.

- A. Trench
- B. progressive slope
- C. shredded waste
- D. bale

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Answers to Sample Written Examination Questions Operator's Module

<u>Number</u>	<u>Correct Answer</u>	<u>Section Reference</u>
1.	A	Section 1, Part A
2.	D	Section 3, Part N
3.	B	Section 2, Part F
4.	D	Appendix C
5.	A	Appendix C
6.	B	Section 3, Part A
7.	C	Section 3, Part H
8.	B	Section 3, Part G and H
9.	D	Section 3, Part J
10.	B	Section 3, Part M
11.	B	Section 1, Part B
12.	B	Section 1, Part A
13.	B	Section 1, Part A
14.	B	Section 1, Part A
15.	D	Section 1, Part A

APPENDIX E

SAMPLE WRITTEN EXAMINATION QUESTIONS--MANAGER'S MODULE

Sample Written Examination Questions Manager's Module

1. Is the following statement true or false?

Surface water must be controlled to minimize the amount of water entering the active waste disposal areas and to protect the final cover over filled areas.

- A. True
- B. False

2. Is the following statement true or false?

An engineered containment system, if properly designed and constructed, will prevent all leakage from a landfill.

- A. True
- B. False

3. If the permeability of the bottom layer or natural subsoils at a landfill facility equals 1×10^{-5} cm/sec, the facility's final cover shall have a minimum permeability of ____

- A. 1×10^{-5} cm/sec
- B. 1×10^{-6} cm/sec
- C. 1×10^{-7} cm/sec
- D. 1×10^{-8} cm/sec

4. Vegetative cover serves the following functions:

- A. Evapotranspiration
- B. Improves the appearance of the site
- C. Protects the final cover
- D. All of the above

5. If erosion of the final cover is discovered during a post-closure inspection, the operator should:

- A. Monitor the damaged area for a minimum of six (6) months and document any changes that occur
- B. Wait until the end of the post-closure period and then repair the damaged area
- C. Repair the damaged area immediately to prevent water infiltration into the wastes
- D. Contact DEQ to see what should be done

6. The screened interval of a groundwater monitoring well should be constructed such that:
- A. It is completely submerged below the water table at all times of the year
 - B. The top of the screen will remain above the seasonal high water table elevation and the bottom of the screen will remain below the seasonal low water table elevation
 - C. The bottom of the screen remains at least 5 feet above the average water table elevation
 - D. It provides adequate well ventilation

7. Is the following statement true or false?

Groundwater monitoring wells must be designed to yield groundwater samples that accurately represent groundwater quality in the uppermost aquifer.

- A. True
- B. False

8. The type of groundwater monitoring conducted to identify a release is called:

- A. Corrective Action Monitoring
- B. Upgradient Monitoring
- C. Assessment Monitoring
- D. Detection Monitoring

9. Alternate Source Demonstrations are conducted to determine if statistically significant differences between downgradient and background groundwater quality are associated with:

- A. Natural variation in groundwater quality
- B. Errors in sampling or analysis
- C. The statistical evaluation
- D. All of the above

10. Is the following statement true or false?

Groundwater protection standards are used for statistical comparison of upgradient groundwater quality to downgradient groundwater quality.

- A. True
- B. False

11. Which types of sanitary landfill permits are always subject to public notice and comment requirements?

- A. New Permits
- B. Renewal Permits
- C. Closure Permits
- D. All of the above

12. Permit application forms have to be signed by all of the following individuals or their representatives except:

- A. The professional engineer who prepared the application
- B. The land owner/ lien holder
- C. The applicant
- D. The solid waste manager

13. Is the following statement true or false?

The results obtained from a round of methane sampling may be influenced by weather conditions.

- A. True
- B. False

14. Financial Assurance is a guarantee that monies will be available for all of the following except:

- A. closure costs
- B. corrective action costs
- C. legal liability costs
- D. post-closure costs

15. The two main components of landfill gas are:

- A. Methane and hydrogen sulfide
- B. Methane and oxygen
- C. Methane and carbon dioxide
- D. Carbon dioxide and hydrogen sulfide

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Answers to Sample Written Examination Questions Manager's Module

<u>Number</u>	<u>Correct Answer</u>	<u>Section Reference</u>
1.	A	Section 5, Part C
2.	B	Section 5, Part D
3.	B	Section 7, Part B
4.	D	Section 7, Part C
5.	C	Section 8, Part B
6.	B	Section 6, Part B
7.	A	Section 6, Part B
8.	D	Section 6, Part B
9.	D	Section 6, Part B
10.	B	Section 6, Part B
11.	D	Section 4, Part B
12.	D	Section 4, Part A
13.	A	Section 6, Part C
14.	C	Section 9, Part A
15.	C	Section 6, Part A

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